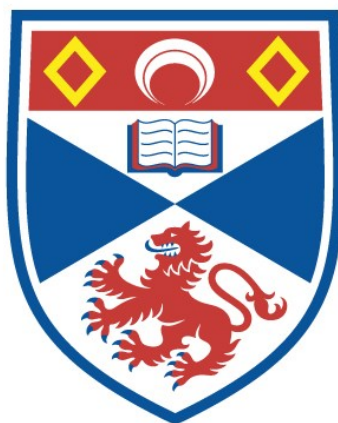


EXAMINING QALY'S : ANALYSING THE USE OF QUALITY  
ADJUSTED LIFE YEARS IN THE ALLOCATION OF HEALTH  
CARE RESOURCES

Stavros Petrou

A Thesis Submitted for the Degree of PhD  
at the  
University of St Andrews



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**STAVROS PETROU**

**A Thesis Submitted for the Degree of Doctor of Philosophy  
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## **Acknowledgments**

I would like to thank Dr. Mo Malek and Dr. Peter Davey for their invaluable supervision and encouragement over the past three years. They have taught me a great deal about health economics and the nature of academic research. My thanks are also due to a large number of colleagues who have assisted me in various ways. In particular, Professor Rowley and all the staff at the Dundee Royal Infirmary who provided access to the patients in the hospital and who supported the study, and Mr. Sinclair for his advice on the statistical techniques applied in the thesis. My thanks also go to Joe Rasquinha and Ho Tung Lee for their willing and efficient help with proof-reading, and to all my family and friends. I acknowledge with gratitude the support of Merrell Dow Pharmaceuticals whose grant enabled me to undertake this degree.

This thesis is dedicated to my family

## **Abstract**

This thesis examines the use quality adjusted life years (QALY'S) in the allocation of health care resources. It is divided into three broad sections. The first section discusses how health status measurement techniques can be used to derive the utility values incorporated into QALY'S. The second section uses one health status measurement instrument, the Rosser-Kind Classification of Illness States, to estimate the QALY'S gained by patients who have undergone hip and knee joint replacement surgery. It is shown that the Rosser-Kind Classification of Illness States is as effective in measuring the health-related quality of life of these patients as more detailed questionnaires. In addition, it is found that further research is required before any generalisations concerning the acceptability of retrospective data can be made. A third important result is that there are significant improvements in health-related quality of life following both types of surgery, with the highest Rosser-Kind rating scores achieved after the first year following knee replacement surgery and after the second year following hip replacement surgery. The third section of the thesis performs an extensive sensitivity analysis on the widely-quoted cost utility estimates for seven medical procedures, calculated by Gudex (1986). The estimates are shown to be sensitive to Gudex's conversion of health outcome data into the Rosser-Kind Classification, her assumptions concerning the survival period / life expectancy following each of the medical procedures and the selected discount rate. A more in depth analysis is then performed on the cost utility estimate for one of the seven procedures, ceftazidime treatment of cystic fibrosis. It is demonstrated that the health outcome and cost assumptions underlying the cost utility estimate for this procedure are not supported by the medical literature. Finally, the thesis raises a number of issues for discussion.

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## **CHAPTER 1**

### **INTRODUCTION**

Health economics is a relatively modern science. Mooney (1986) defined it as the discipline of economics applied to the topic of health. Since the ethical bases of these two subjects are distinct, one may argue that they are incompatible. However, with scarce resources available to meet the infinite demand for health care, the importance of a subject which attempts to tackle resource allocation problems within the health sector is in little doubt. Indeed, the importance of health economics is likely to increase in the future as a result of the changing demographic structures of Western populations and the high levels of modern medical technology costs in the world market.<sup>1</sup>

Within health economics, the forms of analysis which have been applied to health programmes tend to fall into five categories [Drummond et al. (1987)]. *Cost analysis* is the simplest of these techniques. It only deals with the costs of programmes and ignores their consequences. The costs incorporated into such analyses include *direct costs*, which cover labour costs, drug costs and other health care costs and *indirect costs* which cover the costs of lost production. A third category of costs, *intangible costs*, or the monetary value placed on the pain and suffering resulting from an illness, is usually ignored because of the difficulties involved in its calculation.<sup>2</sup> *Cost minimization analysis* compares the costs of two or more programmes whose consequences are shown to be identical. *Cost effectiveness analysis* compares the costs of a programme to its consequences, which are measured in natural or physical units, such as life years saved or hospital days saved. *Cost benefit analysis* compares the costs of a programme to its consequences which are valued in monetary terms. As in the case of costs, the economic consequences of a programme fall into three groups: *direct benefits*, which are the savings to the health sector because the health programme avoids a lower consequential use of resources; *indirect benefits*, which represent the production gains to society

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<sup>1</sup> Financial Times, Friday January 24, 1986.

<sup>2</sup> A detailed discussion of the cost components of health programmes is presented in Chapter 6.

as a result of people returning to work; and *intangible benefits*, which represent the monetary benefits resulting from a reduction in pain and suffering. The latter category is usually ignored by studies because of its complexity. *Cost utility analysis* is a form of cost effectiveness analysis which measures the consequences of programmes in terms of utility-weighted time units.

The form of analysis selected by health economists depends on the information available to them and the viewpoint of the study. If no information on the consequences of a health programme is available, then only a cost analysis can be performed. If the benefits of a programme are expressed in physical units, then either a cost minimization analysis or a cost effectiveness analysis can be performed. More often than not, the former form of analysis is restricted to comparisons within specialized clinical fields. The latter can be applied in any clinical field, but is not very helpful in assessing single programmes, or in comparing disparate alternatives whose consequences are measured in alternative physical units. Cost benefit and cost utility analyses are sophisticated techniques in that they allow all programmes to be compared using a common denominator. However in practice, cost benefit analysis is usually restricted to calculating a limited range of costs and benefits [Drummond et al. (1987)]. Cost utility analysis is the most exciting technique in health economics in that it allows all health programmes to be compared in terms of their costs and the health improvements they procure. These health improvements are usually measured in terms of a single weighted measure, *quality adjusted life years* or QALY's which combine the survival periods and health-related quality of life states accruing from medical programmes.

This thesis is concerned with the increasing use of quality adjusted life years in deciding how health care resources should be allocated within the cost utility framework. It endeavours to examine how the utility values

incorporated into quality adjusted life years are derived using health status measurement techniques, how they could be used to estimate the relative cost effectiveness<sup>3</sup> of medical procedures and how they have been used (in perhaps inadvertently a misleading manner).

Chapter 2 provides a detailed synopsis and exposition of the techniques which have been used to measure health status. Five broad approaches are outlined: the willingness to pay approach, decision analytic techniques, the use of existing utility values available in the medical literature, a range of measurement techniques (the rating scale technique, the standard gamble approach, the time trade-off approach, the equivalence method and ratio scaling) and the use of health status indices. Examples are provided to illustrate how these techniques are used in practice. Particular attention is focussed on one health status index, the Rosser-Kind Classification of Illness States [Rosser and Kind (1978), Kind et al. (1982)], primarily due to its prominence in the field of Health Economics and its relevance to this thesis. The latter part of Chapter 2 explains how cardinal<sup>4</sup> utility values have been derived from these health status measurement techniques, and how these utility values have been used as a method of assessing preferences for alternative health states within the quality adjusted life year unit.

In Chapter 3, the Rosser-Kind Classification of Illness is tested as a health status index on a selected group of patients. It is used to estimate the preoperative and postoperative health-related quality of life of patients who had undergone hip and knee joint replacement surgery. This chapter has four main aims. First, to compare the use of the Rosser-Kind Classification of Illness States with detailed questionnaires as tools of measurement in health-related quality of life estimates. Second, to test for the reliability of using

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<sup>3</sup> In this context, the term *cost effectiveness* is used as an adjective.

<sup>4</sup> Cardinal scales are sets of numbers which allow the strength of the preference for each number to be compared. They will be discussed in Chapter 2 and, in detail, in Chapter 7.

retrospective data as opposed to prospective data when estimating the improvements in health-related quality of life in patients who had undergone hip and knee joint replacement surgery. Third, to calculate the scale of change in health-related quality of life in these two groups of patients, with QALY's used as the method of estimation. Fourth, to use the results to estimate the time period over which the maximum improvements in health-related quality of life are achieved.

Chapters 4 to 6 consider the use of QALY's by Gudex (1986), as means of determining the efficient allocation of scarce health care resources, and illustrate how the approach may inadvertently be used to present misleading results. These chapters should be read in conjunction with each other. Chapter 4 performs an extensive sensitivity analysis<sup>5</sup> of Gudex's cost utility calculations for seven medical procedures: continuous ambulatory peritoneal dialysis (CAPD), haemodialysis, treatment of cystic fibrosis with ceftazidime, kidney transplantation, shoulder joint replacement surgery, scoliosis surgery for idiopathic adolescents and scoliosis surgery for neuromuscular illness. Gudex's main arguments are outlined and the underlying assumptions of her study discussed. The chapter then performs a sensitivity analysis of Gudex's conversion of the health outcome data (she had obtained from the medical literature for each of the seven procedures), into the Rosser-Kind Classification. In addition, sensitivity analyses are also performed on her assumptions concerning the survival period / life expectancy following each of the seven medical procedures and the chosen discount rate<sup>6</sup>.

Chapter 5 conducts a more in depth analysis of Gudex's cost utility estimate for one of the seven medical procedures, cystic fibrosis treatment with ceftazidime. After a detailed sensitivity analysis of Gudex's assumptions

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<sup>5</sup> A sensitivity analysis varies parameters over plausible ranges to determine the robustness of one's results.

<sup>6</sup> The discount rate reduces future costs and benefits to present values. This concept will be discussed in more detail in Chapter 4.

concerning the procedure, the chapter then proceeds to analyse the validity of these assumptions in relation to clinical evidence. In particular, the efficacy of antibiotic treatment of cystic fibrosis patients, as revealed by ten placebo controlled antibiotic trials, is used to test Gudex's assumptions with respect to patient distress, patient disability and survival.

Chapter 6 focuses on the cost assumptions in Gudex's study. A case study is presented of the costs of hospital acquired infection to illustrate the cost components that can be calculated in economic evaluations. The chapter then follows on from Chapter 5 by analysing Gudex's cost estimate for ceftazidime treatment of cystic fibrosis. Using the same placebo controlled antibiotic trials that were analysed in Chapter 5, the cost structures of the different modes of antibiotic treatment are revealed and compared to Gudex's result.

Finally, Chapter 7 presents a summary of the main results of the thesis and considers a number of topics for discussion. These fall into four main categories. First, the use of health status indices, disease-specific and generic, in economic evaluations. Second, the implications of discounting future costs and benefits to present values. Third, the use and abuse of the QALY concept for allocating health care resources and fourth, the problems that arise in the collection of original data. The thesis ends with a presentation of a number of suggestions which are felt would assist health care evaluators and decision makers.

## CHAPTER 2

### TECHNIQUES USED IN HEALTH STATUS MEASUREMENT

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## 2.1 Introduction

Much of the literature in Health Economics has concentrated on measuring the costs and benefits of health care programmes. Until recently, little attention was paid to measuring health status itself, even though it is a major problem in health care evaluations. This chapter will review and critically appraise the five broad approaches to the quantitative valuation of health improvement which have emerged. They are the willingness to pay approach, decision analytic techniques, the use of existing values of health status available in the medical literature, a range of measurement techniques and the use of health status indices. Particular emphasis shall be placed on one health status index, the Rosser-Kind Classification of Illness States. Throughout the chapter, it shall be assumed that associated problems, such as the selection of the appropriate subjects to make the valuations and the comprehensiveness of the descriptions of each health state, have been overcome. An annotated bibliography of all the studies referred to in this chapter is presented in Appendix 1.

## 2.2 Willingness to Pay Approach

The first approach to measuring the value of improvements in health status can be described as the *willingness to pay or willingness to receive approach*. In this approach, the benefits of a health care programme are estimated on the basis of the total amount individuals are willing to pay for the health improvement itself. Likewise, compensation for a diminution in health status can also be estimated by use of, for example, the calculation of pay premiums received by workers in dangerous occupations. One advantage



of this approach is that people are familiar with answering willingness to pay questions for goods or benefits in everyday life.

Willingness to pay estimates can be obtained in a number of ways depending on the context. The alternatives include asking consumers themselves through the use of questionnaires, directly observing their behaviour in the marketplace, inferring from their behaviour and the use of models.

A noticeable feature of the health economics literature is the paucity of articles which apply the willingness to pay/receive approach. Acton (1973) provides the earliest example of the approach by examining the willingness to pay for a programme of mobile coronary care units that were designed to reduce the risk of death from a heart attack. The sample of 100 respondents was made up of citizens of the city of Boston, trade union leaders and upper-level city executives. They were asked how much they were willing to pay for the programme if it reduced their probability of dying from a heart attack by two thousandths (0.002). The average response was \$119 (1973 prices), implying an average value of life in this sample of \$59,000.

A further example of willingness to pay methodology applied to a clinical study is that of Thompson et al. (1984). In this study, 184 patients with osteoarthritis and rheumatoid arthritis were asked their willingness to pay for a hypothetical complete cure of chronic arthritis. Subjects were chosen by stratified random sampling from a rheumatology clinic. They were asked how much they were willing to pay for the complete cure in terms of US dollars each week, as well as a percentage of their family's total weekly income. The interviews lasted for an average of 50 minutes. With minimal pressure and possibilities for revision of earlier answers, the response rate was only 27 percent. The average willingness to pay amongst this group was 17 percent of family income.

The paucity of the willingness to pay/receive literature is largely due to the practical difficulties involved in measuring willingness to pay. According to Thompson et al. (1984), "noncomprehension by subjects, misrepresentation of preferences, extraneous determinants of answers, and ethical concerns" (page 195) deter the use of the approach. Klarman (1982) argues that there are two main difficulties with ascertaining willingness to pay estimates in the health field. One difficulty is the general free-rider problem "of respondents dissembling their true preferences for a public good that is desired by many individuals, in the hope that others would pay for it" (page 589). A second difficulty is that individuals may not accurately perceive and assess risks and benefits. In their survey of 77 senior year undergraduate students, Muller and Reutzel (1984) questioned the assumptions "that people employ rational considerations when responding to willingness to pay questions and that they are capable of matching their responses with the functional relationship (proportionality) underlying implied value of life calculations" (page 808). One ethical concern is that since willingness to pay estimates are constrained by individuals' ability to pay, the wealthy might be given an unproportional influence in determining which programmes were carried out. Likewise, the underlying values of individuals capable of responding rationally to willingness to pay questions might be given an unproportional influence.

### 2.3 Decision Analysis

A second approach to measuring health status is *decision analysis*. Decision-analytic techniques have been increasingly used in the medical field to measure health status. They provide a coherent framework for aiding decisions under conditions of uncertainty by replacing complex decisions with a series of simpler decisions and by using the maximization of expected

utility as the criterion for selection. The method deals with difficult problems by dividing them into components and structuring these components into logical decision trees. Decision makers then attempt to solve them by providing values and probabilities to the more manageable components.

Elstein et al. (1986) provide an eloquent summary of the technique: "Decision analysis is a formal analytic framework that is increasingly being applied to the problem of selecting an action in clinical situations in which the optimal choice is not intuitively clear or the judgments of competent physicians differ. These situations often involve complex combinations of uncertainty, values, risks, and benefits, precisely where human judgment may encounter difficulty in reaching an optimal solution and where a decision aid may be useful. The techniques and principles of clinical decision analysis constitute a family of tools for the logical analysis of such complex clinical situations. Selecting a management plan is accomplished by a detailed analysis of the available alternatives and their potential consequences, the criterion for selection being the maximization of expected utility, a quantitative measure of preference. Clinical decision analysis has been applied to a variety of medical problems to determine how to treat or work-up a specific patient, to analyze management alternatives for certain problems, and to assess the value of diagnostic tests" (page 246).

As is clear in the above quote, the use of decision analysis as a tool in valuing the health status of individuals with different clinical conditions has usually formed only a component of general option appraisal of alternative medical procedures. An early example of the application of decision analysis to a clinical study was its use by Pauker (1976) as an aid in the management of individual patients with chronic ischemic heart disease. Specifically, the approach was used to evaluate the choice between coronary artery bypass surgery and medical therapy. The study considered a set of 48 prototypical analyses. This set was composed of 12 clinical cohorts which were in turn

subdivided into 4 groups of patient preferences. The model of prognosis encompassed many published data about both forms of medical treatment. The authors estimated a preference for coronary surgery amongst many patients with disabling angina, but it was not found to be the preferred therapy in asymptomatic patients. Final decisions were strongly affected by patient preferences.

The decision analytic model constructed by Pauker and Pauker (1977) allowed prospective parents to make hypothetical decisions concerning mid-trimester amniocentesis for prenatal diagnosis. The technique was applied to the prenatal diagnosis of Down's syndrome, meningomyelocele and Duchenne muscular dystrophy. Parents were asked to consider their relative preferences for five possible outcomes: an unaffected child, an affected child, spontaneous abortion, therapeutic abortion of an unaffected fetus and therapeutic abortion of an affected fetus. The parents decisions were aided by medical consultation on the likelihood of the birth of a child affected by a genetic disorder, the risk of amniocentesis and the probability that the diagnoses provided by the amniocentesis will be correct.

Stason and Weinstein (1977) used a decision analysis model to determine the efficient use of resources within programmes to treat hypertension. The alternative forms of treatment considered were the screening and treatment for hypertension versus no organised screening programme. The information given concerning the assumed effectiveness of each mode of treatment was the number of physician visits, investigations, length of hypertension treatment, and the mortality and morbidity benefits. Effectiveness was calculated in terms of increased life expectancy, with a quality adjustment incorporated in order to reflect treatment side-effects. A year of life with side-effects was assumed to be equivalent to 0.99 of a healthy year, with this assumption varied in a sensitivity analysis. The authors also made three assumptions concerning the reduction of risk of high blood

pressure. When assumptions concerning the costs of each programme were incorporated, the study concluded that improving patient adherence was the more cost effective procedure.

The study by Weinstein et al. (1977) used decision analysis methodology to develop a structural framework that assists decision makers in deciding whether or not to offer coronary artery bypass surgery to patients. The framework allows decision makers to incorporate their own subjective assessments as well as hard data in reaching their decisions. The authors used the information available in the medical literature as well as their own subjective judgments to illustrate the probability assessments offered by the model for five hypothetical patients. They argued that the patients typified the spectrum of cases that might be presented as surgical candidates. Sensitivity analyses were performed on their probability assessments with the result that surgical mortality was the parameter with the single most important effect. Though the model is limited by the use of subjective data, it does illustrate the technique of decision analysis for evaluating clinical procedures.

Pliskin et al. (1980) made several assumptions to develop alternative forms of bivariate utility functions of life years and health status. The derived utility functions were then used in deciding whether or not to apply coronary artery bypass graft surgery in patients with coronary artery disease, with the result that patient attitudes towards risks on longevity influenced the choice of treatment.

The study by Weinstein (1980) incorporated hypothetical subjective evaluations of the effects of estrogen use on the health-related quality of life of postmenopausal women. Postmenopausal women were defined as women aged over fifty years and mostly in whom the uterus was in situ and for whom the risk of endometrical cancer thus existed. Based on evidence in the medical literature, the author assumed that symptomatic improvement was

equivalent to 0.01 of a healthy year. The benefits of treatment were shown to depend on whether the women had prior hysterectomies or osteoporosis, and on the subjective values assigned to symptomatic relief.

Expanding on their study of a year earlier, Pliskin et al. (1981) applied decision-analytic techniques to assist them in choosing between an autocoronary bypass operation and medical management in fourteen hypothetical patients with varying degrees of coronary artery disease. The factors incorporated into the decision framework included the physical and psychological characteristics of each patient, the availability of operative treatment and its quality, and the relative benefits and risks of the alternative forms of treatment. The probability estimates for each of the factors incorporated into the framework were obtained from two cardiologists and one cardiac surgeon, though the study does not reveal what those estimates were. Patient preferences were incorporated by assigning utility values to alternative trade-offs between life expectancy and health-related quality of life. The framework favoured operation for 13 of the 14 hypothetical patients, but there were discrepancies between the clinical judgments of the physicians and the derived estimates using the decision-analytic techniques. This is explained by the absence of angina in selected patients.

Decision analytic techniques were used by Torrance and Zipursky (1984) to estimate the effectiveness of antepartum prophylaxis of rhesus (Rh.) immunization in the province of Ontario, Canada. By not making quality adjustments for the life years gained by a sample of 1,000 pregnant women, the authors estimated that a comprehensive antepartum prophylaxis programme would be cost effective in comparison with other health care expenditures.

Decision analysis methodology was also used by Williams (1985) to determine the future level of operations for coronary artery bypass grafting. By using the subjective valuations of three cardiologists concerning the

severity of angina and type of disease in a group of hypothetical patients who had or had not undergone surgery, Williams was able to determine the relative cost effectiveness of coronary artery bypass graft surgery compared to heart transplantation, the treatment of endstage renal failure and hip replacement surgery.

Another example of the application of decision analysis in the medical literature is a well presented, hypothetical scenario in the study by Weinstein (1986). This study uses decision flow diagrams to illustrate the choices involved in the alternative treatments for chronic progressive liver failure. However, as the author himself indicates, a number of assumptions are incorporated into the scenario which may not be appropriate. For example, the scenario has been formulated in such a way as to avoid the application of value judgments to the alternative outcomes. The issue of resource constraints is avoided. Moreover, it is not clear how the probabilities of the success or failure of the alternative forms of treatment were obtained. Any such probabilities must themselves incorporate the subjective judgments of experts.

The advantages of the decision analysis approach are that it is fast and relatively inexpensive. Physicians (or other health care evaluators) can use their expert knowledge to construct a decision framework which provides values for alternative health states. However, one's results should be thoroughly scrutinized by the use of sensitivity analysis. In any health care evaluation, the robustness of the final decision should be tested over a range of plausible values and probabilities. If large variations in these values or probabilities for alternative health states do not significantly alter the results of the health care evaluation, then confidence in the results is increased. Elstein et al. (1986) question the applicability of the decision analysis approach in complex, multivariate environments. They argue that in situations with multiple objectives in which it is unclear how to take all of them into

account, actual decision behaviour will often follow the course of action implied by the most important objective because such choices are more easily justified. They also argue that decision analysis may not be an adequate descriptive theory where issues of responsibility and regret are concerned. Weinstein (1986) doubted the widespread acceptance of decision analysis methodology by medical practitioners and health care administrators. Possible reasons for this are argued to be the limited quality of information about the effects of clinical procedures in heterogeneous populations, the incomplete understanding of the value and preferences of patients and potential users of health care, the imperfectly structured incentives for cost effective resource use in both the public and private health care systems and the frustrations often felt by clinicians at the task of assigning explicit values and probabilities, especially when the empirical data base is deficient.

## 2.4 Medical Literature

A third approach to measuring health status is the *use of existing values available in the literature*. This approach is relatively quick, straightforward and inexpensive though it is not as reliable as the utility measurement approach since it is difficult to ensure that the health states, subjects and measurement instruments used match those of one's own study. A number of studies in the medical literature report utility values. The study by Kaplan et al. (1976) reports utility values for 36 different health states, ranging from no symptoms or problems to a loss of consciousness such as seizures, fainting or comas (out cold or knocked out). Sackett and Torrance (1978) present social utility values for 10 different health states: depression, home confinement for tuberculosis, home confinement for an unnamed contagious disease, hospital confinement for tuberculosis, hospital confinement for an unnamed



contagious disease, hospital dialysis, home dialysis, kidney transplant, mastectomy for breast cancer and mastectomy for injury. By contrast, Pliskin et al. (1980) presented utility values for varying degrees of angina. A further example of a study which presented utility values for a specific illness is that of McNeil et al. (1981) who reported utility values for loss of speech due to laryngeal cancer. Torrance et al. (1982) presented utility values for different combinations of physical activity, role activity, social activity and health problems. A more recent example of the presentation of utility values in the medical literature is the study by Read et al. (1984) who presented utility values for no angina, moderate angina and severe angina.

## 2..5 Measurement Techniques

The fourth approach to measuring health status is through *measurement techniques* themselves. As Torrance (1986) points out, "this involves the identification of health states for which utilities are required, the preparation of health state descriptions, the selection of subjects, and the use of a utility measurement instrument" (page 11). The most frequently used methods of measuring health status have been rating scales, the standard gamble approach and the time trade-off approach. Two additional techniques, equivalence and ratio scaling, have been used less regularly. These methods are described below.

### (a) Rating Scale Technique

The *rating scale technique* is a relatively straightforward method of measuring health status. Typically, individuals are offered several case-descriptions covering a wide range of health states and are asked to assign

values to them on a line whose endpoints have already been defined. The ratings correspond to the individual's preference values for the alternative health states.

Individuals rate the alternative health states such that the interspaces between them correspond to their perceived differences in preferences. The scale is standardized between 0 and 1 where zero usually represents 'death' and unity 'perfect health'. However, some health states have been rated as even worse than death [Boyle et al. (1983)]. In this case, death is located on the scale between the two endpoints. Preferences for temporary health states can also be rated using the same principle. Torrance et al. (1982) have developed sophisticated props, such as 'health thermometers', to aid respondents to assign values.

Drummond et al. (1987) describe how an individual might use the technique to rate a group of health states: "The subject is asked to select the best health state of the batch, which presumably would be 'normal healthy life' and the worst state, which may or may not be 'death at age of onset'. He is then asked to locate the other states on the rating scale relative to each other such that the distances between the locations are proportional to his preference differences. The rating scale is measured between 0 at one end and 1 at the other end. If death is judged to be the worst state and placed at the 0 end of the rating scale, the preference value for each of the other states is simply the scale value of its placement. If death is not judged to be the worst state but is placed at some intermediate point on the scale, say  $d$ , the preference values for the other states are given by the formula  $(x-d)/(1-d)$ , where  $x$  is the scale placement of the health state" (page 125).

A related procedure to the rating scale technique is *category scaling* in which subjects assign health states to alternative categories rather than to points on a line. The same principle applies in terms of the scale value of the location of each category. Kaplan et al. (1979) describe this technique as

efficient, easy to use, and applicable in a large number of laboratory and survey settings.

Bush et al. (1973) report the use of the rating scale technique by 11 nationally recognised phenylketonuria (PKU) authorities for 15 function levels of mental retardation. Each consultant used their expert knowledge to assign weights to the function levels on a scale which ranged from 0 for death to 1 for well. Group consultation allowed the consultants to make revised estimates, after which the means were used as the group judgment. A similar procedure was also carried out by a group of graduate students in nursing and health administration using the category scaling technique.

The development of the Index of Well-being by Kaplan et al. (1976) will be discussed on page 32. This study applied the rating scale technique on a sample of 867 citizens of San Diego to measure the utility values for 36 different health states, so as to determine the validity and reliability of their classifications into the 43 function levels. Each of the 867 subjects were interviewed, as were 370 children and 89 dysfunctional persons later identified.

#### (b) Standard Gamble Approach

The *standard gamble approach* to measuring health status is derived from the axioms of utility theory first conceived by Von Neumann and Morgenstern (1947) and later developed by Keeney and Raiffa (1976). It basically requires individuals to choose between hypothetical lotteries as a means of measuring their utility for specific health states.

The hypothetical lotteries that subjects are asked to consider involve a choice between two alternatives; the certain outcome of surviving for a fixed period and a chance or gamble with two possible outcomes (death or survival for a longer period). The probability of successfully surviving for the longer

period is varied until the subject is indifferent between the two alternatives at which point his utility for the health state can be calculated. Slightly different approaches are used to assess states worse than death and temporary health states. Because untrained people experience difficulties in understanding gambles, the approach is often supplemented with visual aids such as 'probability wheels'.

Torrance et al. (1972) explained the standard gamble approach as follows: "The subject is asked to choose between two alternatives: alternative 1, the certainty of good health for time  $t$ , then state  $n-1$  for time  $t$ , followed by death; and alternative 2, the gamble of good health for time  $t$ , followed by use of a hypothetical drug with a probability  $p$  of keeping the subject completely asymptomatic for time  $t$ , followed by death, and a probability  $1-p$  of causing immediate death. The probability  $p$  is varied to locate the point at which the respondent is indifferent between these two alternatives. At this indifference point the utilities of the two alternatives are equal and the utility of state  $n-1$  may be calculated as follows:

$$h_1t + h_{n-1}t = h_1t + h_1tp + h_nt(1-p)$$

Since by definition  $h_1 = 1$  and  $h_n = 0$ , this simplifies to

$$h_{n-1} = p$$

The apparently superfluous requirement that in each alternative the respondent begins by being healthy for time  $t$  is in fact necessary to ensure that all times the respondent is dealing with his future death and never with his immediate death. This precaution not only improves the reliability of the resultant utilities but is also consistent with their eventual use: the utilities are to be used in planning decisions concerning future health programs, consequently the trade-offs to be evaluated will all be in the future" (pages 122-123).

As Pauker and McNeil (1981) inform us, if a subject is prepared to accept a certain survival time which is less than the average return expected on the

gamble, he is described as 'risk averse'; if he is prepared to accept a certain survival time which is equal to the average return, he is described as 'risk neutral'; if he is prepared to accept a certain survival time which is greater than the average return, he is described as 'risk seeking'.

An early example of the standard gamble approach in the medical literature is its application by McNeil et al. (1978) to 14 patients with operable lung cancer. The primary treatment of 6 of these patients had included a recent operation, whilst the other 8 patients had received radiation therapy only. The standard gamble approach was used to elicit their attitudes towards survival for varying periods. This involved offering patients 50:50 choices between fixed periods of certain survival and gambles on longer periods of survival. It was found that patients were quite risk averse towards the probability of immediate death. The data on patient attitudes were then combined with survival data for the two types of treatment to obtain a relative measure of efficacy, called expected utility. The final results suggested a patient preference for radiotherapy with patient age, operative mortality and the quality of surgical results all having major effects on the choice of therapy.

Eraker and Sox (1981) used the standard gamble approach to characterize patient preferences to drug therapy. The study questioned 523 subjects, all of whom were patients at a variety of California clinics, about their attitudes to three pairs of therapeutic outcomes. Each scenario offered patients the choice between two drugs with equivalent effects. One drug offered a certain outcome, whilst the other offered two possible outcomes. The first was a large therapeutic effect, and the second was no therapeutic effect at all. Most patients tended to be risk averse when a positive therapeutic effect was on offer, that is they tended to opt for the certain and intermediate outcome. However, when the drug effects were adverse, patients exhibited risk seeking behaviour and were willing to take more of a risk in order to have a chance at experiencing the most positive outcome on offer.

Breyer and Fuchs (1982) also used the standard gamble approach to investigate the risk behaviour of individuals in the health dimension. A sample of 325 individuals were questioned about their attitudes to 12 hypothetical scenarios. In each scenario, the individuals were offered choices between 2 alternative forms of treatment for a supposed illness. One treatment offered a fixed health effect. The other treatment offered two possible outcomes (a more favourable and a less favourable health effect). As in the study by Eraker and Sox (1981), the authors found that individuals exhibit risk averse behaviour towards positive health outcomes and risk seeking behaviour towards negative health outcomes.

Elstein et al. (1986) used the standard gamble, rating scale and category scaling approaches in their comparison of physicians' decisions regarding estrogen replacement therapy for menopausal women and derived decisions from a decision analytic model. Fifty physicians used the rating scale approach to indicate the utility values they would place on 12 cases representing menopausal women. Their decisions were then compared with a decision analytic model that included 5 possible treatment regimens and 3 possible treatment outcomes. The subjective probabilities required for the model were elicited using the category scaling and standard gamble approaches. The results of the study indicated differences between the two types of decisions.

### (c) Time Trade-Off Approach

The *time trade-off approach* was developed by Torrance, Thomas and Sackett (1972) to measure health state utilities. Like the standard gamble approach, it attempts to elicit subjects' preference values for alternative health states in an implicit manner.

The core of the technique involves asking subjects to consider the relative amounts of time they would be willing to trade in order to survive in various

health states. The choice may lie between continuing in a present defined state of ill health or moving to a shorter but healthier life. The duration of the shorter but healthier state is varied until the subject is indifferent between the two alternatives, at which point his utility for the health state can be calculated.

Torrance et al. (1972) described the technique as follows: "Here the respondent is asked to choose between two alternatives of certainty: alternative 1, state  $n-1$  for time  $t$ , followed by death; and alternative 2, good health for time  $x$  less than  $t$ , followed by death. The respondent's indifference point is located by varying the time  $x$ . The average utility for state  $n-1$  over time period  $t$ ,  $h_{n-1}$ , is again determined by equating the utilities of the two alternatives:

$$h_{n-1}t = h_1x + h_n(t-x)$$

$$h_{n-1} = x/t "$$

(Page 124)

Torrance et al. (1972) also explain the application of this method to any state  $i$  other than state  $n-1$ . "The two certainty alternatives are alternative 1, state  $i$  for time  $t$ , followed by good health; and alternative 2, state  $i + 1$  for time  $x$  less than  $t$ , followed by good health. The required utility is calculated from  $h_i = 1 - x/t(1 - h_{i+1})$ " (page 124).

Slightly different approaches can be used to assess chronic health states preferred to death, chronic health states considered worse than death, and temporary health states. In addition, props such as laminated boards aid the technique.

The time trade-off approach has been incorporated into a number of studies. The model developed by Pliskin et al. (1980) was described on page 13. Decision-analytic techniques were used to develop alternative forms of bivariate utility functions. An empirical assessment of these utility functions used the time trade-off and standard gamble approaches to decide whether or

not to prescribe coronary artery bypass graft surgery in patients with coronary artery disease. There were ten subjects whose utility values formed the basis of the study results, nine of whom were academics and one of whom was a guest. The subjects were asked seven questions in total. The first six questions asked subjects the minimum number of years they were willing to trade in return for relief from anginal pain. The final question offered patients a lottery by asking them how many additional years of life for certain they would value equivalent to a 50:50 chance of living for either 5 or 15 years. Five of the subjects exhibited risk neutrality, three exhibited risk proneness and two risk aversion, implying real differences in the utility values of the respondents.

Another example of a study which used both the time trade-off and standard gamble approaches to measure utility values is that of McNeil et al. (1981). As in the earlier study by the authors [McNeil et al. (1978), page 21], the expected utility of a sample of subjects was measured to assist in the choice between two alternative treatments. The sample was made up of 37 healthy volunteers, 25 of whom were middle and upper management executives and 12 of whom were firemen. The treatment choice was between surgery and radiation therapy for laryngeal cancer. To obtain individual preferences for the two types of treatment, the subjects were asked a series of questions using the standard gamble and time trade off techniques. First they were asked to consider their response to a hypothetical choice between an intermediate period of certain survival and an equal chance of a much longer period of survival and death in a few months. They were then asked a series of questions concerning the proportion of certain survival they were willing to trade in order to retain their normal speech. When the results on patient utilities were combined with data on the results of various treatment strategies, the authors obtained a much clearer picture of the relative values for the alternative treatments. This study indicated that to maintain their



voices, approximately 20 percent of volunteers would choose radiation therapy instead of surgery even though radiation therapy was associated with a lower survival rate.

The multi-attribute model was tested by Torrance et al. (1982) on 112 parents of school children. In interviews the subjects were asked to value the seven different combinations of the 4 attributes between 0 and 1, where 0 represented death and 1 healthy. They were asked to imagine that they would survive in such hypothetical health states for a lifetime. With the aid of printed cards and reference levels, the subjects used the time trade off and category scaling methods to provide utility values for each of the seven health states. Some of the chronic dysfunctional states were rated as worse than death. As a result, the range of utility values extended from 1 to -0.39.

Weinstein and Stason (1982) used the time trade off approach in their cost effectiveness analysis of coronary artery bypass surgery. Without measuring the utilities on a sample of patients, the authors used the information available in the medical literature to assume that patients with severe angina are willing to trade 1 year of discomfort with 0.7 of a pain-free year. However, the cost effectiveness of surgery was shown to be sensitive to the varying of this proportion between 0.5 and 1.0.

Buxton et al. (1986) illustrated that the time trade-off approach is practicable by testing the method on a group of 114 subjects. In interviews which lasted for an average of 20-25 minutes, the subjects were asked to place five alternative descriptions of a woman with breast cancer and a description of a woman in full health in rank order from the best to the worst situation. Then, with the help of visual aid, they were asked how many years of each of the five 'post-cancer' health states they were willing to trade in order to survive in the full health situation. There was a considerable degree of consistency in the rank order of the health states between the subjects.

However, the results section of the study does not state the average number of years subjects were willing to trade.

#### (d) Other Measurement Techniques

Two additional techniques, equivalence and ratio scaling, have also occasionally been used to measure health state utilities. According to the *equivalence technique*, preference values for alternative health states are measured by asking subjects to relate groups of people in alternative health states. For example, subjects are asked how many sick people in one health state are equivalent in total health status to a given number of perfectly healthy people. In this way, all health states can be related to each other in terms of utilities. Bush et al. (1973) used the equivalence technique in their cost effectiveness analysis of a phenylketonuria screening programme.

*Ratio scaling*, which is very similar to the equivalence method, provides a ratio comparison of health states. Here the subject is asked to provide a value that represents the ratio of the desirability of each health state to an arbitrarily chosen one. The reference state is assigned a random value from which the preference values of the other health states can be calculated. In this way the preference values for all the health states can be represented on a scale. Ratio scaling has only been used in one published study (Rosser and Kind, 1978).

#### (e) Comparability of Measurement Techniques

Since different measurement techniques may lead people to construct diverse preference values for the same health states, it is important to question which technique is superior.

The advantages of the rating scale and category scaling techniques are their efficiency, straightforwardness, wide applicability and the fact that they are

quick and inexpensive to employ. However, as Read et al. (1984) inform us, there is a temptation for subjects to spread their responses evenly across categories. "Experimental evidence indicates that one factor affecting category scaling responses is a desire to use all categories of the scale equally often" (page 325).

Because the standard gamble approach is derived from the axioms of utility theory and introduces risk into the assessment task, it is often argued that it has advantages over other methods. Certainly, the introduction of risk into the measurement procedure permits a method of combining indices of components of the characteristics bundle of 'health' into an over-all index. This may prove advantageous in some applications. However, as Culyer (1978) points out "...a possible disadvantage is that the health status index is itself not merely a function of the characteristics on the axes but also of the judges' attitudes to risk...In descriptive studies, where the actual state of health is the focus rather than affecting some change in status, attitude to risk may distort the 'pure' trade-offs between dimensions of ill-health."

The standard gamble approach is relatively time-consuming and people often have difficulties understanding the concept of probabilities. Moreover, preference values can be strongly influenced by the way questions are framed [Read et al. (1984)].

Despite the fact that the time trade-off approach is reliable, practicable, simpler to understand and use than the standard gamble approach, and that it can be justified by the axioms of utility theory under certain conditions and can provide a relatively cost-effective way of measuring health state utilities, it does have some drawbacks. As Rosser and Kind (1978) inform us, the approach is based on the assumptions that the perception of time is linear and that the perception of the severity of illness is independent of the time spent in this state. "This clearly becomes untenable when dealing with states such

as unconsciousness which are acceptable for short periods but unacceptable for very long ones" (page 348).

In addition, the trade-off concept is difficult for many people to understand. Does a subject who says that he would be willing to live a shorter but healthier life really mean that he would be willing to die earlier? It may be that he hasn't fully considered the consequences of his answers. Moreover, Fein (1977) argues that it is unclear what implications the method has in questions of choice, when ethical questions are asked.

Studies reported in Torrance (1986) and Read et al. (1984) found the reliability of all the measurement techniques to be satisfactory. In addition, the standard gamble approach was found to be valid by definition whilst the time trade-off technique was relatively valid according to the definition used and the rating scale method was not at all valid.

## 2.6 Health Status Indices

The fifth health status measurement approach involves the use of *health status indices*. These indices or scales are essentially weighting schemes which assign weights to each definable health status. The source of these weights is ultimately subjective, that is researchers themselves precisely predetermine what they consider to be adequate indicators of health status and the relative importance of each constituent component of disability and discomfort.

A number of health status indices have been developed based on the premise that health status is a complex, multidimensional phenomenon. The 'Karnofsky Index of Performance Status' [Karnofsky et al. (1948)] is the earliest example of a widely-used health status index. Originally developed to classify the functional status of patients with cancer, the index interprets a patient's health-related quality of life in terms of physical ability. Three criteria were

used to assess physical ability: patient's ability to work, patient's ability to pursue what the authors describe as 'normal activity' and patients' ability to care for themselves. The classification was divided into eleven categories which covered varying degrees of ability to pursue these activities, ranging from 0 representing dead, to 1, representing 'normal'.

A more generic health status index was developed by Grogono and Woodgate (1971) with the expressed aim of measuring health and allowing severity of disease, efficacy of treatment and costs to be compared. As in the example by Karnofsky et al. (1948), the index varied numerically between 0 and 1. However, in this index, 0 represented 'extreme ill-health' and 1 'normal'. Patients were assessed with respect to 10 activities which were thought of as comprehensive pattern of daily life. The activities were work, recreation, physical suffering, mental suffering, communication, sleep, dependency on others, feeding, excretion and sexual activity. Each activity received a score of either 1, 0.5 or 0, representing normal, impaired, or incapacitated respectively. No intermediate points of assessment were used. The total was then divided by 10 to yield a final score of between 0 and 1. By multiplying any period of time by this weighting factor, the authors argued, the benefits resulting from any medical treatment could be expressed in terms of 'health-years' gained. Initial observations with the index on 27 patients by 20 observers (including consultants, registrars, housemen and students) produced scores which varied between 0.25 for a man with severe asthma and 1.0 for a man awaiting admission for excision of a tongue papilloma. There was only a slight variation in the scores of the observers.

The 'Harris Index' was developed by Harris et al. (1971) to assess the effects of physical, mental and sensory handicap in the British population on the ability to obtain work, need for health and welfare support. It was based on the results from interviews with 12,738 subjects between October 1968 and February 1969. These subjects had been narrowed down from an earlier, much

larger, sample of 250,000 households. Severity of handicap was classified into 8 categories, three of which related to those who needed special care and the remaining five related to specified dimensions. The degree of severity of each function was categorised by the subjects themselves, the interviewers merely providing the descriptions.

The 'Ability Index' developed by Izsak and Medalie (1971) provides a wide-ranging and comprehensive follow-up assessment of carcinoma patients. The index is composed of 15 parameters. Seven parameters measured the subjective reactions and feelings of each patient: pain, prosthesis, sleep, frequency of visits to physician, everyday self-care ability, sexual relationships and the degree of ambulation. Three parameters measured the working ability and earning capacity of each patient: actual earnings relative to income prior to illness, whether the patient returned to previous work or changed occupation and attitude (satisfaction) to work. Five parameters measures the social adjustment of each patient: husband-wife relationships, parent-child relationships, relationships to other relatives, wider social relationships and feeling of well-being. Each of the 15 parameters received a score of either 0, 1, 2 or 3 points, with 0 representing the worst possible scenario and 3 the best possible scenario. The overall scores therefore could vary between 0 and 45 points. The emphasis is placed on the clinician to perform the scoring.

Breslow (1972) made a brave attempt to apply the World Health Organisation definition of health ( a state of physical, mental and social well-being, not merely the absence of disease or infirmity) to health outcome measurement. After an initial survey involving 6,928 adults in Alameda County, California, three indices of physical, mental and social well-being were constructed. The measure of physical health was a seven-point spectrum. The categories in the spectrum ranged from 1, representing severe disability, to 7, representing a physical state without any complaints. An eight-item index measured health, based on five negative and three positive

feelings. The measure of social health incorporated employability, marital satisfaction, sociability and community involvement. The three indices provided independent but complementary indicators of health status.

Patrick et al. (1973) constructed a comprehensive health status index incorporating 29 function levels. Using the method of category scaling (to be explained later), 31 registered nurses and 31 graduate students without a medical background assigned values to health state descriptions. The health state descriptions comprised various combinations of physical activity, mobility and social activity. The social activity scale comprised 5 components which ranged from an ability to perform major and other activities to a requirement of assistance with self-care activities. The mobility scale also comprised five components, which ranged from an ability to travel freely to a state of being restricted to a special unit. The physical activity scale comprised four components, ranging from an ability to walk freely to a state of being restricted to bed or chair for most or all of the day. The values for the health state descriptions were then transformed into a 0-1 scale. Zero represented death, whilst one represented optimum function. The study demonstrated differences between the two groups of judges and between function levels.

The 'Sickness Impact Profile' [Bergner et al. (1976)] was conceptualized as an instrument which would provide a descriptive profile of the responses of a given individual in terms of the specific behavioural impacts of sickness. After much sorting and grouping of potential items, the instrument was reduced to 312 items in 14 categories. The 14 categories were social interaction; ambulation or locomotion activity; sleep and rest activity; taking nutrition; usual daily work; household management; mobility and confinement; movement of the body; communication activity; leisure pastimes and recreation; intellectual functioning; interaction with family members; emotions, feelings, and sensations; and personal hygiene. Subjects were asked to respond only to the items which they felt described them on the day of

evaluation, and were related to their health. The results of initial pilot studies were transformed into 11-point and 15-point scales, which ranged from minimally dysfunctional to severely dysfunctional, with high agreement amongst judges.

The 'Activities of Daily Living Index', developed by Katz and Akpom (1976) is a good example of a health status index created for a variety of diagnoses. It measures a patient's health-related quality of life in terms of six functions: bathing, dressing, feeding, continence, transfer and toileting. For each function, patients are categorised as either independent or dependent, independence defined as an ability to perform the function without supervision, direction, or active personal assistance. The index summarizes overall performance into grades A, B, C, D, E, F, G or 'Other' where A represents independence in feeding, continence, transferring, going to the toilet, dressing and bathing, and G represents dependence in all six functions. The category 'Other' represents dependence in at least two functions, but not classifiable as C, D, E or F. The authors argue that this category usually includes less than 5% of patients. The ability of each patient to perform each function without supervision is decided upon by an observer.

The 'Index of Well-being' was created by Kaplan et al. (1976) to fulfil the definition of content validity as it applies to health status measures. It is made up of two components, level of well-being and prognosis, the latter representing the probability of attaining a level of well-being by a certain time. The index classifies individuals into a continuum which ranges from optimum function (weighted 1.0) to death (weighted 0.0), using 43 function levels which are combinations of mobility, physical activity and social activity scales.

Sackett et al. (1977) developed a health status index "designed to measure the social, emotional, and physical function of free-living populations" (page 423). The subjects whose health state valuations formed the basis of the index



were family members in the general practice of one of the five investigators. There were 296 subjects in total, all aged 15 years or over. All subjects were interviewed in their homes for a mean duration time of 40 minutes. They responded to detailed questionnaires which contained 64 items related to social function, 41 items related to emotional function and 35 items related to physical function, as well as questions related to respiratory and joint symptoms, cigarette use, and a series of sociodemographic variables. In addition to these questionnaires, the family physician of each subject completed assessment forms with respect to their physical, social, emotional and family function, total health and predicted future health. These clinical assessments were based entirely upon reviews of clinical records and the memory of each physician. The agreement between subject and physician assessments was then calculated. The subjects' responses to the questions related to social and emotional function were then standardized into separate social and emotional indices which ranged from 0 to 1, where 0 represented 'extremely poor function' and 1 'extremely good function'. It is argued that these indices can be used to compare patients with a variety of diseases.

The Spitzer quality of life index or QL-Index [Spitzer et al. (1981)] aims to assist physicians in assessing the relative benefits and risks of various medical procedures. The authors mention palliative care and hospice care as examples of procedures to which the index is suited. They make clear, however, that it is not suitable for measuring the health-related quality of life of a healthy population. It is composed of five items (activity, daily living, health, support and outlook on life) which are transformed into a 0-10 scale. The authors do not clarify whether the items are given equal weights in the scale. The index was tested by more than 150 physicians on 879 Australian and Canadian patients, with high inter-rater correlation coefficients. The median time of completion of the index was just one minute.

Six years after first constructing the 'Index of Well-being', Kaplan and Bush (1982) were also instrumental in the creation of a new unit of health status, the 'Well-Year'. This unit measures health outcome across two dimensions, the length of survival and health-related quality of life produced by a health programme. The latter is estimated using the 29 function levels constructed by Patrick et al. (1973). When balanced against the cost of each programme, the 'Well-Year' allows cost-utility comparisons to be made. Kaplan and Bush (1982) provide one of the earliest examples in the medical literature of the importance of such measurements.

Torrance et al. (1982) use the multi-attribute utility method [Keeney and Raiffa (1976)] to measure health status. They define health status according to a four-attribute health state classification system. The four attributes were mobility and physical activity, self-care and role activity, emotional well-being and social activity and health problems. The mobility and physical activity attribute was subdivided into six levels, ranging from being able to get around the house, yard, neighbourhood or community without help from another person and having no limitation in physical ability to lift, walk, run, jump or bend to needing help from another person in order to get around the house, yard, neighbourhood or community and not being able to use or control the arms and legs. The self-care and role activity attribute was subdivided into five levels, ranging from being able to eat, dress, bathe and go to the toilet without help and having no limitations when playing, going to school, working or in other activities to needing help to eat, dress, bathe or go to the toilet and not being able to play, attend school or work. The emotional well-being and social attribute was subdivided into four levels, ranging from being happy and relaxed most or all of the time and having an average number of friends and contacts with others to being anxious or depressed some or a good bit of the time and having very few friends and little contact with others. The health problem attribute was subdivided into eight levels, ranging from

having no health problem to being blind or deaf or not able to speak. The classification was tested on 112 parents of school children who were asked to value seven different combinations of the four attributes between 0 and 1, where 0 represented death and 1 healthy (the method of valuation in this study shall be explained later in the chapter).

The 'Nottingham Health Profile' was developed by Hunt et al. (1985). It is a short and straightforward index which is divided into two parts. Part 1 comprises 38 statements which fall into six areas: sleep, physical mobility, energy, pain, emotional reactions and social isolation. Part 2 comprises 7 statements which relate to paid employment, jobs around the house, social life, personal relationships, sex life, hobbies and interests, and holidays. Respondents are required yes to each statement if it applies to them and no if it does not. Each statement is weighted to give a maximum score of 100 for each part of the index, with a score of 100 representing maximum severity of perceived problems in that area. The authors argue that the profile is useful in evaluating the outcomes of medical interventions, but it is limited in that zero scores for each statement do not necessarily indicate total absence of distress. Hence, the profile is not useful in measuring mild forms of distress.

A more recent health status index was developed by Bulpitt and Fletcher (1990) to measure the effects of antihypertensive treatment on the health-related quality of life of hypertensive patients. The health index measured the disability of the patients on a continuum from 0 to 1, where 0 represented death and 1 total well-being. The numerical values given to the different states of disability were as follows: total well-being (1.0), minor dissatisfaction (0.975), discomfort (0.875), minor disability (0.8), major disability (0.75), disabled (0.625), confined (0.375), bedridden (0.125), isolated (0.025), comatose (0) and dead (0). The measurement techniques used in the derivation of these scores were the time trade off and standard gamble techniques which shall be explained later.

Finally, a measure of health status which has not yet been completed is the 'euroqol instrument' [Euroqol Group (1990)]. This contains 6 distinct dimensions of health: mobility, self-care, main activity, social relationships, pain and mood. The mobility dimension has 3 categories: no problems walking about, unable to walk about without a stick, crutch or walking frame and confined to bed. The self-care dimension has 3 categories: no problems with self-care, unable to dress self and unable to feed self. The main activity dimension has 2 categories: able to perform main activity (e.g. work, study, housework) and unable to perform main activity. The social relationships dimension has 2 categories: able to pursue family and leisure activities and unable to pursue family and leisure activities. The pain dimension has 3 categories: no pain or discomfort, moderate pain or discomfort and extreme pain or discomfort. The mood dimension has 2 categories: not anxious or depressed and anxious or depressed. The instrument was tested on groups of patients in pilot studies in the UK, the Netherlands and Sweden by asking patients to rate 16 of the 216 possible combinations of the health-related quality of life dimensions on a visual analogue scale similar to a thermometer. Early results indicate striking similarities between the relative valuations attached to the health states.

These scales can be used to measure the health status of individuals and can be applied to the economic appraisal of health care programmes. They have the advantage that they overcome the multidimensional nature of health-related quality of life. However, Spitzer et al. (1981) outline the methodological problems involved in the use of such scales. According to this author, they "...are usually lengthy; require specially-trained research personnel to administer, code and store the information; were generally developed by experts on the basis of their own views of the appropriate dimensions to be included; are frequently oriented to physical function with insufficient attention to social and emotional aspects of quality of life; have

often been applied in only one disease or one health problem; have limited use outside the original research setting because physicians find them too long or complicated for routine, period assessment of patients; and have not always been validated, this is especially true of the shorter ones" (pages 586-587). Drummond (1989) questions their sensitivity in picking up small improvements in the health-related quality of life associated with some treatments. In their analysis of the Karnofsky Index of Performance Status, Hutchinson et al. (1979) found that "the major sources of observer variability appeared to be the lack of operational criteria to define the major elements of the scale and the nonexhaustive aggregation of the scale's constituent elements" (page 661). Moreover, Culyer (1978) argues that these measures incorporate value judgments which appear not to be identically shared by individuals in the community.

## 2.7 Rosser-Kind Classification of Illness States

One health status index which has had a major impact on health status measurement issues in recent years is the *Rosser-Kind Classification of Illness States* developed by Rosser and Kind (1978) and Kind et al. (1982). Its importance, not only for the field of health-related quality of life measurement but also for this thesis, merits a separate section and detailed explanation.

The Rosser-Kind Classification of Illness States is based on two dimensions of health, disability and distress, where disability is defined as the extent to which a patient is judged to be unable to pursue the activities of a normal person, and distress is defined as a patient's pain and mental suffering in relation to disablement, anxiety and depression [Rosser and Watts (1975)]. The classification divides the disability dimension into the following eight

categories: I no disability; II slight social disability; III severe social disability or slight impairment of performance at work, able to do all housework except very heavy tasks; IV choice of work or performance at work severely limited, housewives and old people able to do light housework only but able to go out shopping; V unable to undertake any paid employment, unable to continue any education, old people confined to home except for escorted outings and short walks and unable to do shopping, housewives only able to perform a few simple tasks; VI confined to chair or wheelchair or able to move around in the home only with support from an assistant; VII confined to bed, and VIII unconscious (Table 2.1). The classification also divides the distress dimension into four categories: none, mild, moderate and severe (Table 2.1). In total, the Rosser Classification contains 29 descriptions of health status. The reason for 29 (rather than 32) categories is that, by definition, unconscious patients cannot be in distress.

Rosser and Kind (1978) interviewed 70 subjects with the expressed aim of allotting utility values to each of the 29 states of illness. The subjects included 10 patients from medical wards, 10 psychiatric in-patients, 10 experienced state registered general nurses, 10 experienced state registered psychiatric nurses, 20 healthy volunteers and 10 doctors sufficiently experienced to have gained a membership or fellowship of at least one Royal College. Each interview began with a discussion of the context of the experiment. The subjects were then required to make pairwise comparisons of the different combinations of disability and distress, using the ratio scaling method. They were assisted with the use of typed cards, and were invited to discuss any implications or discrepancies associated with their conclusions. The interviews lasted between 1.5 and 4.5 hours, with some subjects indicating at the end that they found the experience painful and disturbing. Kind et al. (1982) transformed

the median results of the 70 interviews into an interval scale<sup>1</sup>. The transformed scale had endpoints of 0 and 1 where 0 represented death and 1 represented fit. The valuations of pairwise combinations of disability and distress are listed in Table 2.2. It is noticeable that two of the health states (VIID and VIIIA) were rated as worse than death. The results for the different groups of subjects were highly variable with doctors, in particular, placing less emphasis on the importance of death.

The Rosser-Kind Classification has been criticised on a number of grounds. Gudex (1986) argues that the utility values were estimated by too small a sample, and that the subjects themselves were unrepresentative of society as a whole. In addition, she argues that the disability scale can be construed as ambiguous. For example, in which disability category would one place a wheelchair-bound patient who is able to work full time and without impairment? Further criticisms of the classification include the emphasis placed on paid employment, the insufficient descriptions which assess the health-related quality of life of children, the mentally handicapped and the elderly, and the omission of features of quality of life such as marriage satisfaction and role fulfilment.

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<sup>1</sup> An interval scale has fixed endpoints and tells us that one unit differs by a certain amount of a property from another unit.

TABLE 2.1: ROSSER-KIND CLASSIFICATION OF ILLNESS STATES

DISABILITY		DISTRESS	
I	NO DISABILITY	A	NO DISTRESS
II	SLIGHT SOCIAL DISABILITY	B	MILD
III	SEVERE SOCIAL DISABILITY AND/OR SLIGHT IMPAIRMENT OF PERFORMANCE AT WORK. ABLE TO DO ALL HOUSEWORK EXCEPT VERY HEAVY TASKS.	C	MODERATE
		D	SEVERE
IV	CHOICE OF WORK OR PERFORMANCE AT WORK VERY SEVERELY LIMITED. HOUSEWIVES AND OLD PEOPLE ABLE TO DO LIGHT HOUSEWORK ONLY BUT ABLE TO GO OUT SHOPPING.		
V	UNABLE TO UNDERTAKE ANY PAID EMPLOYMENT. UNABLE TO CONTINUE ANY EDUCATION. OLD PEOPLE CONFINED TO HOME EXCEPT FOR ESCORTED OUTINGS AND SHORT WALKS AND UNABLE TO DO SHOPPING. HOUSEWIVES ABLE ONLY TO PERFORM A FEW SIMPLE TASKS.		
VI	CONFINED TO CHAIR OR TO WHEELCHAIR OR ABLE TO MOVE AROUND IN THE HOUSE ONLY WITH SUPPORT FROM AN ASSISTANT		
VII	CONFINED TO BED		
VIII	UNCONSCIOUS		

Source: Kind et al. (1982)



**TABLE 2.2: ROSSER VALUATION MATRIX**

DISABILITY RATING	DISTRESS RATING			
	A	B	C	D.
I	1.000	0.995	0.990	0.967
II	0.990	0.986	0.973	0.932
III	0.980	0.972	0.956	0.912
IV	0.964	0.956	0.942	0.870
V	0.946	0.935	0.900	0.700
VI	0.875	0.845	0.680	0.000
VII	0.677	0.564	0.000	-1.486
VIII	- 1.028			

*Source:* Kind et al. (1982)

## 2.8 From Health Status Measurement Techniques to QALY's

In this chapter, five broad approaches to measuring health status have been described and appraised: the willingness of individuals to pay for alternative health states, decision-analytic techniques, the use of existing values available in the medical literature, a range of measurement techniques and health status indices. Special emphasis was placed on one health status index, the Rosser-Kind Classification of Illness States, because of its importance to the field of health status measurement in general and to this thesis in particular.

The willingness to pay approach places monetary values on the perceived benefits of a medical procedures. However, the other four approaches allow utility values to be placed on alternative health states, that is they allow preferences for the alternative health states to be measured on cardinal scales and to be meaningfully compared in terms of health state utilities. These cardinal scales usually range from 0 to 1 where 0 represents death and 1 represents full health. This information on the relative preferences for alternative health states can be employed in conjunction with survival/life expectancy data to give *quality adjusted life years* [Drummond et al. (1987)].

Quality adjusted life years or QALY's are single weighted measures which combine the survival periods and health-related quality of life states accruing from health programmes. The idea can be illustrated with a simple example. Let us assume that there are two treatments for an illness. Both treatments extend the life expectancy of an individual by 1 year. However, treatment A results in the individual surviving the year in full health (usually represented by a health-related quality of life score of 1.0 on a cardinal scale), whilst treatment B results in the individual surviving the year in a health state with a health-related quality of life score of 0.7 (using any of the four approaches to obtaining health state utilities). Treatment A has led to a gain

in QALY's of 1.0 ( $1 \times 1.0$ ), whilst treatment B has led to a gain in QALY's of 0.7 ( $1 \times 0.7$ ). Benefits accruing beyond the first year are usually discounted to their present values (this topic shall be discussed in Chapter 4).

QALY's have been measured for a number of specific illnesses, usually in combination with cost data and with the aim of aiding resource allocation decisions within specialities. Stason and Weinstein (1977) used QALY data to determine how resources could be used most efficiently within programmes to treat hypertension (the study was discussed on page 12). The alternatives considered were the screening and treatment for hypertension and an organised screening programme at all. A year of life with side effects was assumed to be equivalent to 0.99 QALY's. This estimate was not obtained using a health status measurement approach, but rather was an adaptation of the information available in the Framingham Study [Kannel and Gordon (1970)]. Weinstein (1980) incorporated his own subjective evaluations of the effects of estrogen use on the health-related quality of life of postmenopausal women. By assuming that symptomatic improvement was equivalent to 0.01 QALY's, the author estimated that treatment was relatively cost effective in certain women. However, the subjective values assigned to symptomatic relief were critical to the final cost effectiveness results. Weinstein and Stason (1982) also used information available in the medical literature to estimate that a year of life with severe angina was equivalent to 0.7 QALY's. However, once again, their final cost effectiveness estimate for coronary artery bypass surgery was very sensitive to their quality weight. Decision analytic techniques were used by Boyle et al. (1983) to adjust the costs of neonatal intensive care of very low birth weight infants. In this study, costs per life year gained of \$2,900- \$9,300 were adjusted to costs per QALY gained of \$3,200- \$22,400.

A few studies have used QALY data to compare the relative cost effectiveness of different health care programmes. In these studies, the health

outcome data should be obtained using the same measurement techniques, thus facilitating across-programme comparisons. Torrance and Zipursky (1984) list the costs per QALY gained of 14 health care programme reported in the medical literature. The results ranged from a negative figure for PKU screening to \$54,000 for hospital haemodialysis. All costs had been converted to their equivalent 1983 amounts using the US consumer price index for medical care. However, methodological differences remained with respect to the discount rate, preference weights, method of costing and selection of patients used in each of the studies. The decision analysis methodology used by Williams (1985) to determine the future level of operations for coronary artery bypass grafting was discussed on page 14. This study summarizes the costs and benefits of alternative medical treatments in terms of costs per QALY gained, ranging from £750 for hip replacement surgery to £14,000 for hospital haemodialysis (all costs at 1983-1984 prices). Gudex (1986) used information available in the medical literature to estimate the relative cost effectiveness of seven medical procedures. The costs per QALY gained for these procedures ranged from £194 for surgery for scoliosis secondary to neuromuscular illness to £13,434 for CAPD (1986 prices).

## CHAPTER 3

### JOINT REPLACEMENT STUDY

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### 3.1 Introduction

Our interest in the Rosser-Kind Classification of Illness States led naturally to a desire to use the classification to measure the health-related quality of life of a specific group of patients. Patients who had undergone hip and knee joint replacement surgery were chosen because of their accessibility and because the procedure is, at present, frequently performed at a nearby hospital (Dundee Royal Infirmary). The aims of the study were fourfold. First, to compare the use of the classification with detailed questionnaires as tools of measurement in health-related quality of life estimates. Second, to test for the reliability of using retrospective data as opposed to prospective data when estimating the improvements in health-related quality of life in patients who have undergone hip and knee joint replacement surgery. Third, to calculate the scale of change in health-related quality of life in these two groups of patients, with quality adjusted life years (QALY's) used as the method of estimation. Fourth, to use the results to estimate the time period over which the maximum improvements in health-related quality of life are achieved.

### 3.2 Methods

The study was carried out at the Dundee Royal Infirmary between May 1990 and February 1991 and was divided into two parts. A control sample of 44 patients were interviewed twice, preoperatively and at three months postoperatively. Of the 44 patients, 19 were male, 25 female; 23 had hip replacements and 21 knee replacements. Table 3.1 (page 47) shows the number of patients who fell into each operation site and sex subgroup. The average age of the 44 patients at the time of their operation was 68 (66 for the males, 70 for the females). At each of the two interviews, the purpose of the study was explained verbally and the 44 patients were asked a range of questions

pertaining to their health-related quality of life at that time. At the postoperative interview, the patients were again questioned about their health-related quality of life prior to their operation.

**Table 3.1: Control Group: Number of Patients by Sex and by Operation Type**

	Males	Females	Total
Hips	13	10	23
Knees	6	15	21
Total	19	25	44

The second sample was made up of 159 patients who were interviewed retrospectively at three months, one year or two years after their operation. Of the 159 patients, 51 were male, 108 female; 116 had hip replacements, 43 knee replacements; 30 were interviewed three months after their operation, 71 one year after their operation and 58 two years after their operation. Table 3.2 shows the number of patients who fell into each operation site and sex subgroup. The average age of the 159 patients at the time of their operation was 66 (65 for males, 66 for females). The 159 retrospective patients were interviewed once only, but each interview was divided into two parts. The first section asked the patients about their health-related quality of life at that point in time; the second about their health-related quality of life prior to their operation. Again, the purpose of the study was explained verbally to each patient once the interview had commenced.

**Table 3.2: Retrospective Group: Number of Patients by Sex and by Operation Type / Interview Interval**

	Males	Females	Total
Three Month Hips	7	13	20
One Year Hips	12	26	38
Two Year Hips	26	32	58
Three Month Knees	0	10	10
One Year Knees	6	27	33
Total	51	108	159

A copy of the questionnaires used in the interviews can be found in Appendices 2-5. There were four questionnaires in total: a preoperative questionnaire for the hip control group patients (Appendix 2), a preoperative questionnaire for the knee control group patients (Appendix 3), a postoperative and retrospective questionnaire for the patients who had hip replacements in both the control and retrospective groups (Appendix 4), and a postoperative and retrospective questionnaire for the patients who had knee replacements in both the control and retrospective groups (Appendix 5). The first two of the four questionnaires (Appendices 2 and 3) were used solely in the preoperative interviews of the control group patients. The latter two (Appendices 4 and 5) were used in the postoperative interviews of the control group patients and all the interviews of the retrospective group patients.

The interviews lasted for an average of 20 minutes and were conducted by a single interviewer (the writer). At each stage of every interview, the patient was first asked to categorise his or her health-related quality of life according to the Classification of Illness States. This involved the patient placing himself/herself into one Rosser Disability/Distress Category (or in an overlap between two categories) after hearing their descriptions. They were then asked a wide range of questions about their ability to undertake everyday functions which allowed an assessment to be made by the observer of their health-related quality of life using the same classification. The questions related to functions which were particularly affected by arthritis (which most of the patients were suffering from) and were divided into categories which could easily be converted into the Rosser Classification. The response to the question regarding pain, stiffness and swelling in the joint, for example, was divided into none, slight, moderate and severe categories which could easily be converted into Rosser Distress Categories A, B, C and D respectively. The response to the question concerning the impairment of performance at work or choice of work was divided into none, slight, severe and complete



categories which could easily be converted into Rosser Disability Categories I-II, III, IV and V respectively. The five options available to the housework question (able to perform all housework, able to perform all housework except very heavy tasks, able to perform light housework, able to perform a few simple tasks and unable to perform any housework at all) were matched to Rosser Disability Categories I-II, III, IV, V and VI-VIII respectively. The hobbies and sports questions provided information on the social disability of the patients. All the remaining questions helped to build up an overall picture of the disability and distress of each patient and also acted as checks on the validity of answers to other questions. Where the answers seemed to contradict themselves or seemed to place the patient into alternative Disability/Distress Categories, a judgment had to be made on the most appropriate categorisation of the patient based on the totality of answers.

At the end of each stage of each interview therefore, two assessments of each patient's health-related quality of life were available for study. First, the patient's own assessment of their health-related quality of life according to their placement in the Classification of Illness States and second, an observer's assessment of their health-related quality of life based on a conversion of their responses to a wide range of questions into the same classification. In total, six health-related quality of life scores were derived from the two interviews with the control group patients (two health-related quality of life scores at each of the three stages of the interviews), and four health-related quality of life scores were derived from the one interview with the retrospective group patients (two health-related quality of life scores at each of the two stages of the interview).

### 3.3 Control Group Results

A listing of the characteristics of the 44 control group patients is presented in Appendix 6, together with the subject's original prospective Rosser-Kind estimate (rating) of his/her health-related quality of life, the derived prospective Rosser-Kind estimate (rating) of his/her health-related quality of life, the subject's Rosser-Kind estimate (rating) after three months, the derived Rosser-Kind estimate (rating) after three months, the subject's retrospective Rosser-Kind estimate (rating) of his/her health-related quality of life prior to the operation and the derived retrospective Rosser-Kind estimate (rating) of his/her health-related quality of life prior to the operation. Thus, there were six health-related quality of life scores for each control group patient. Three of the scores were derived from the subject's own positioning on the Rosser-Kind Classification at the preoperative, postoperative and retrospective stages. The other three were derived from an assessment of each patient's health-related quality of life at the same stages, based on their answers in the interviews.

#### 3.31 Control Group: Comparison of Rosser Classification with Questionnaires

The first aim of the study was to compare the use of the Rosser-Kind Classification of Illness States with the questionnaires as tools of measurement in health-related quality of life estimates. The most common method of comparing two such measurements is to calculate the correlation coefficient ( $r$ ) between them. Considering the detailed nature of the questionnaires, one might expect the two approaches to yield different results and the correlation coefficient between them to be quite low. However, the correlation coefficients between the patient estimates of their

health-related quality of life (based on their positioning on the Rosser-Kind Disability/Distress Scale) and the derived estimates of their health-related quality of life (based on their responses to the questionnaires) were very high at every stage of the process: 0.899 at the preoperative stage, 0.972 at the postoperative stage and 0.931 at the retrospective stage. In addition, the correlation coefficients between the patient estimates and the derived estimates were high in every category of the operation site and sex subgroups. At the preoperative stage, the correlation coefficients were 0.930 for the hip subgroup, 0.788 for the knee subgroup, 0.893 for the male patients and 0.902 for the female patients. At the postoperative stage, the correlation coefficients were 0.953 for the hip subgroup, 0.989 for the knee subgroup, 0.961 for the male patients and 0.989 for the female patients. At the retrospective stage, the correlation coefficients were 0.947 for the hip subgroup, 0.908 for the knee subgroup, 0.938 for the male patients and 0.944 for the female patients. Though the correlation coefficient measures the strength of a relation between two variables, it does not tell us whether we can reliably use both variables interchangeably. As Bland and Altman (1986) inform us, a more appropriate method would be to test the agreement between the two variables by plotting the difference between them against their mean. Therefore, tests of agreement were conducted between the two variables at each of the three stages of interviews.

#### (a) Preoperative Stage

Figure 3.1 (page 52) displays a simple scatter diagram of the subjects' prospective rating scores and the derived prospective rating scores, with the line of agreement for the two sets of data. Figure 3.2 (page 52) plots the difference between the two sets of data against their mean.

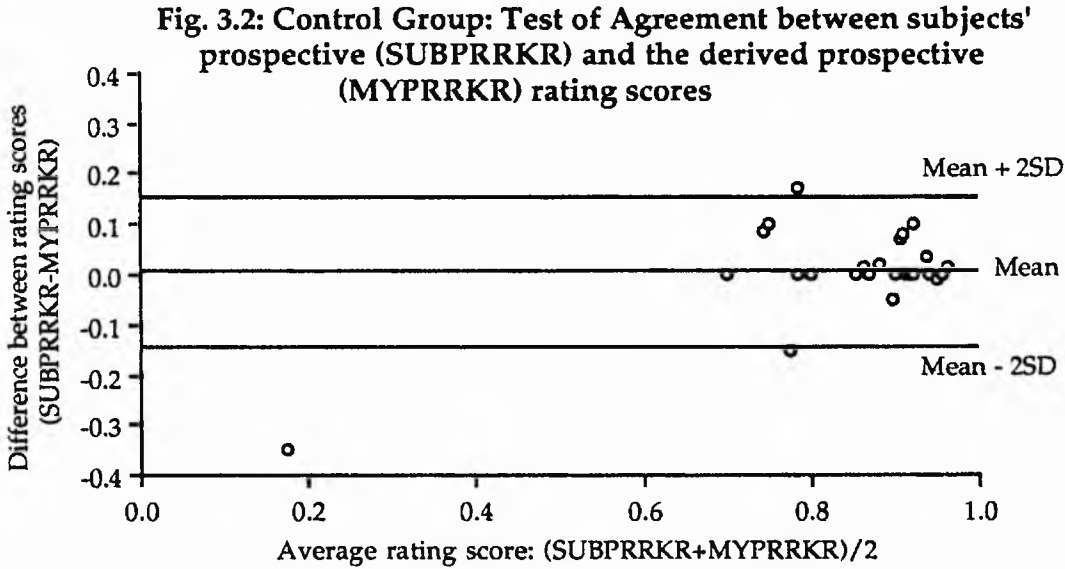
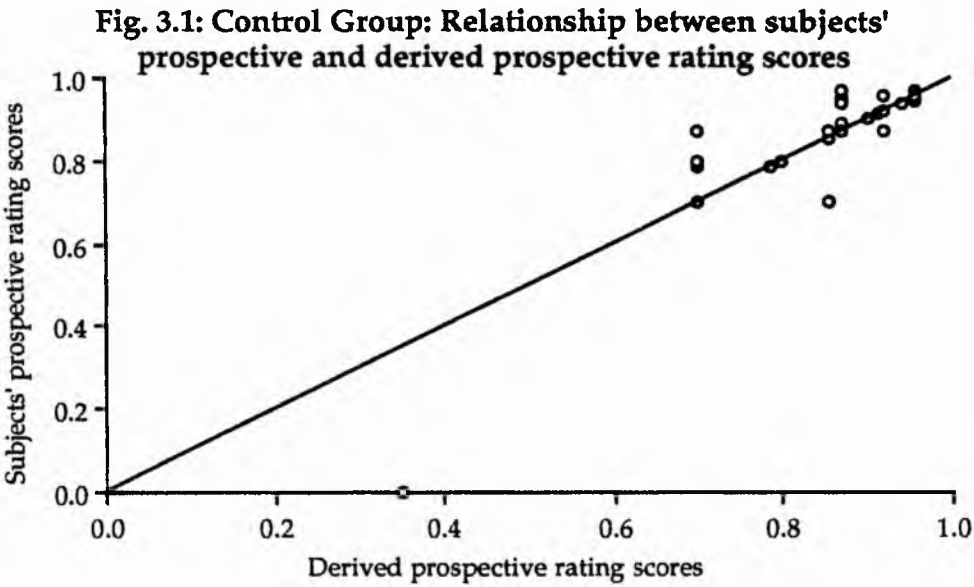
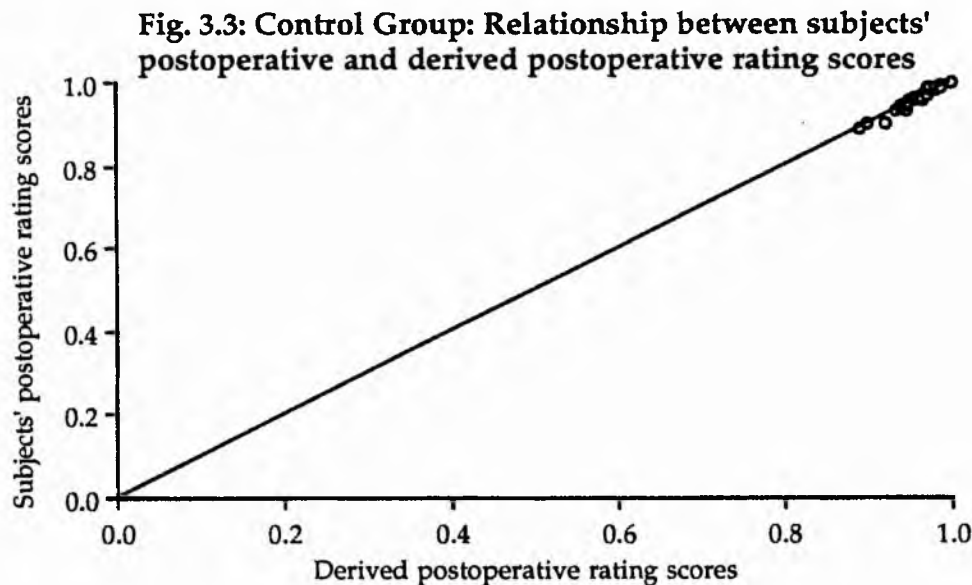


Figure 3.2 shows no clear relationship between the difference and the mean; the difference between the two sets of prospective rating scores neither increases nor decreases as the average rating score increases. In other words, the Test of Agreement does not display any consistent bias over the range of average rating scores. The mean difference between the subjects' prospective and the derived prospective rating scores was extremely small, 0.0034, with a 95% confidence interval of -0.0206 to 0.0273. The limits of agreement were

0.153, with a 95% confidence interval of 0.1115 to 0.1945, and -0.1462, with a 95% confidence interval of -0.1877 to -0.1047. The width of these intervals is the result of two outliers. The line of best fit between the two sets of data,  $y = -0.21153 + 1.2546x$  ( $R^2=0.809$ ), conforms quite strongly to the line of agreement. Moreover, the mann-whitney test found that the probability that there is no difference between the medians of the two sets of prospective scores is 0.2582.

(b) Postoperative Stage

Figures 3.3 and 3.4 (page 54) carry out the same exercise for the relationship between the subjects' postoperative and the derived postoperative rating scores.



**Fig. 3.4: Control Group: Test of Agreement between subjects' postoperative (SUBPORKR) and derived postoperative (MYPORKR) rating scores**

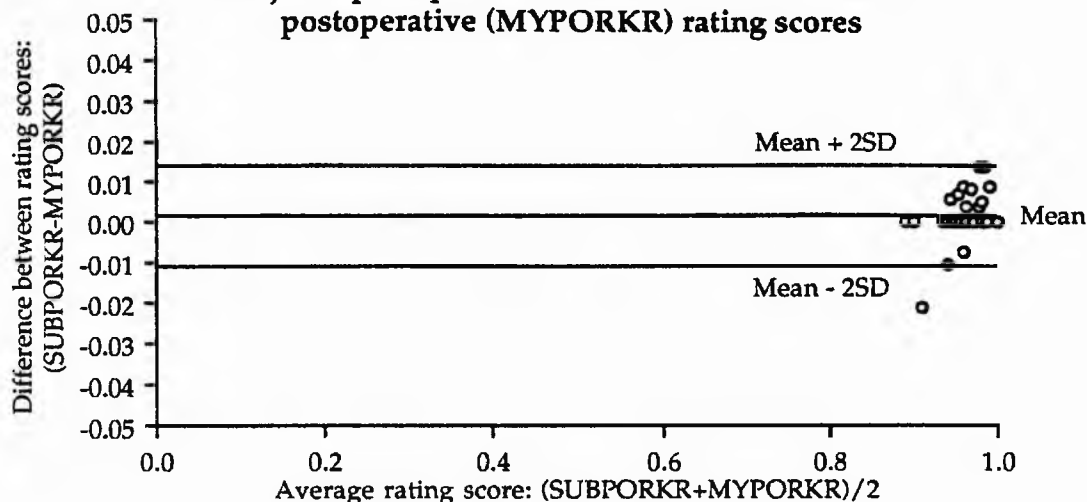
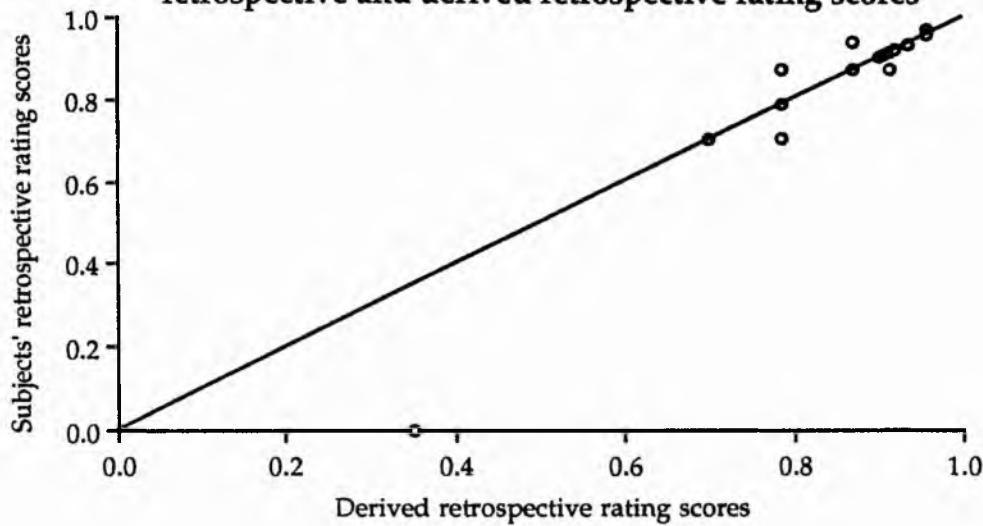


Figure 3.4 displays a very strong agreement between the subjects' postoperative and the derived postoperative rating scores. The mean difference between the two set of postoperative rating scores was 0.00124, with a 95% confidence interval of -0.0009 to 0.0034. The limits of agreement were an extremely narrow 0.0138, with a 95% confidence interval of 0.0101 to 0.0175, and -0.0113, with a 95% confidence interval of -0.0150 to -0.0076. The slope and intercept of the line of best fit between the two sets of data ( $y = -8.2909e^{-2} + 1.0880x$ ,  $R^2 = 0.946$ ) and the mann-whitney test of the difference between their medians (significance level = 0.5089) illustrate the strength of the agreement between them.

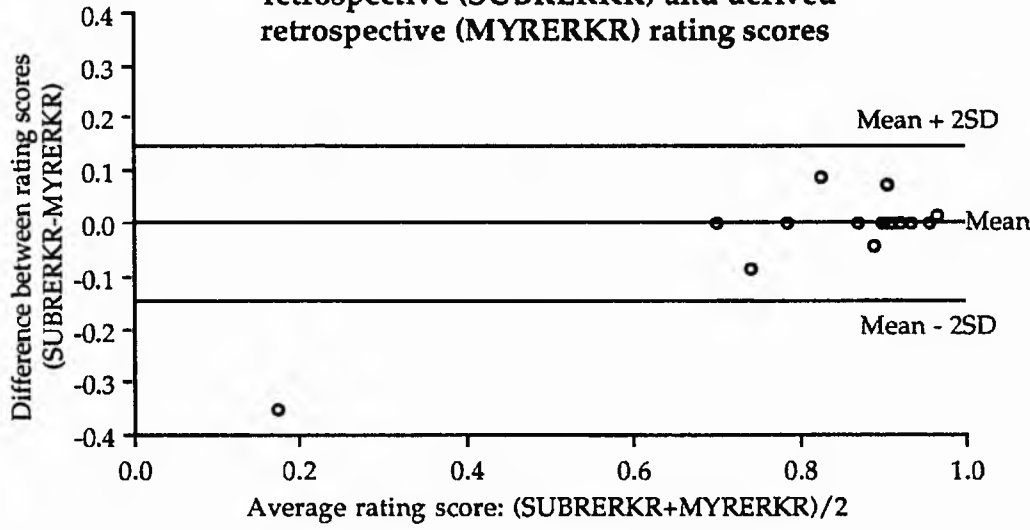
### (c) Retrospective Stage

The two diagrams on page 55 illustrate the relationship between the subjects' retrospective and the derived retrospective rating scores.

**Fig. 3.5: Control Group: Relationship between subjects' retrospective and derived retrospective rating scores**



**Fig. 3.6: Control Group: Test of Agreement between subjects' retrospective (SUBRERKR) and derived retrospective (MYRERKR) rating scores**



No consistent bias is obvious over the range of average retrospective rating scores. The mean difference between the subject's retrospective and the derived retrospective rating scores was -0.0014, with a 95% confidence interval of -0.0264 to 0.0236. The limits of agreement were 0.1442, with a 95% confidence interval of 0.1009 to 0.1875, and -0.147, with a 95% confidence interval of -0.1903 to -0.1037. Moreover, the equation of the line of best fit between the two sets of data ( $y = -0.24529 + 1.3082x$ ,  $R^2 = 0.868$ ) and the mann-

whitney test of the differences between their medians (significance level = 0.8322) again illustrates the agreement between them.

(d) All Stages

Figures 3.1-3.6 illustrate the strength of the agreement between the subjects' estimates and the derived estimates of their health-related quality of life at each stage of the process. It seems therefore that the Rosser-Kind Classification is an excellent indicator of the health-related quality of life of patients who have undergone joint replacement surgery. However, certain points of caution should be introduced at this stage. It may be the case that the Rosser-Kind Classification provides a comprehensive measure of the health-related quality of life of lower limb joint replacement patients. Alternatively, it may be that its crude generic nature may be too insensitive to pick up subtle changes in the health-related quality of life of these patients. For example, most of the patients in this study were elderly and as such, the emphasis in the Classification placed on paid employment may have been superfluous. In addition, though most patients found it relatively straightforward to identify their position on the disability and distress scales, some ambiguity did surround the position of working-age patients who felt unable to undertake any paid employment but could perform all housework except heavy tasks. In such cases, the patient would be placed in the intermediate disability category (IV).

The Rosser-Kind Classification of Illness States was used rather than a disease-specific scale, because it allows us to compare the improvements in health status resulting from joint replacement surgery with those which result from other types of medical treatment. Hence, we can use it to calculate the relative cost effectiveness of joint replacement surgery vis-a-vis other medical procedures. However, its categories may be too broad and general to



pick up small changes in the health-related quality of life of our groups of patients. It may not be surprising therefore that in the conversion process, the information in the questionnaires should conform so strongly to the patients' own positioning in the Classification. Using an alternative disease-specific scale to measure the health-related quality of life of the patients would forgo the cross-programme comparison quality of the Rosser Classification. Moreover, there is little evidence that the assumptions and value judgments underlying alternative scales are any more acceptable than those underlying the Rosser Classification. Based on the information available in our study however, it does seem that the Rosser-Kind Classification is an acceptable basis for measuring the health-related quality of life of patients who have undergone hip and knee joint replacement surgery.

### **3.32 Control Group: Reliability of Retrospective Data**

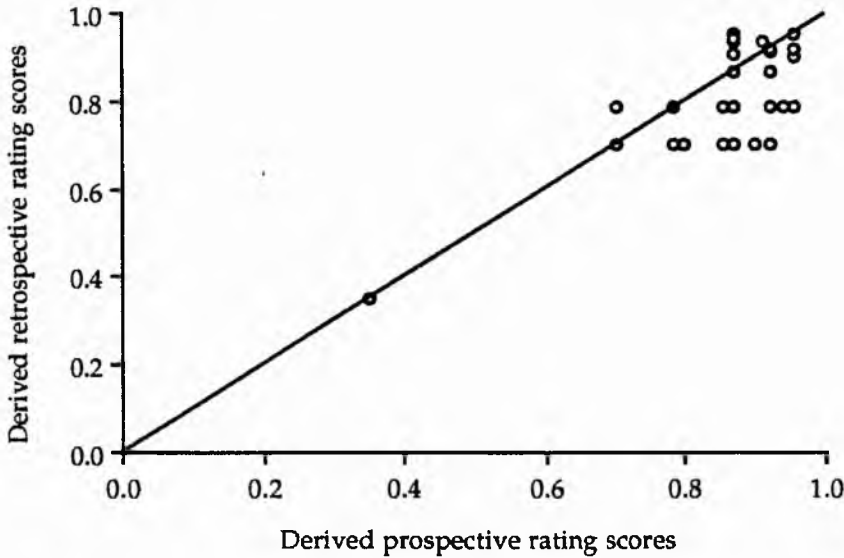
The second aim of the study was to test for the reliability of retrospective data as opposed to prospective data when estimating the improvements in health-related quality of life in patients who have undergone hip and knee joint replacement surgery. If the retrospective rating scores of the control group (estimated at the postoperative interview) compare favourably with the prospective rating scores from the preoperative interview, then we can feel comfortable in our use of retrospective data, and we will be able to extend our analyses to the much larger retrospective sample of patients. The correlation coefficient between the derived prospective Rosser-Kind rating scores (MYPRERKR) and the derived retrospective Rosser-Kind rating scores (MYRERKR) is 0.725. Using the subjects' approximations to the Rosser-Kind Classification, the correlation coefficient between the prospective and retrospective data is 0.832. When the data is broken down into operation site

and sex subgroups however, very different results emerge. The correlation coefficients between the prospective and retrospective sets of data, using the derived estimates were as follows (with the correlation coefficients between the subject's estimates in brackets): hips 0.913 (0.948), knees 0.441 (0.404), males 0.449 (0.309) and females 0.739 (0.890). If the control group is broken down into smaller subgroups, a clearer picture emerges. Using the derived estimates, the correlation coefficients between the prospective and retrospective sets of data were 0.666 for the male hip subgroup, 0.970 for the female hip subgroup, 0.553 for the male knee subgroup and 0.209 for the female knee subgroup. At first sight therefore, the use of retrospective data seems acceptable for patients who have undergone hip joint replacement surgery, but should be used with caution when analysing the health-related quality of life improvements in patients who have undergone knee joint replacement surgery.

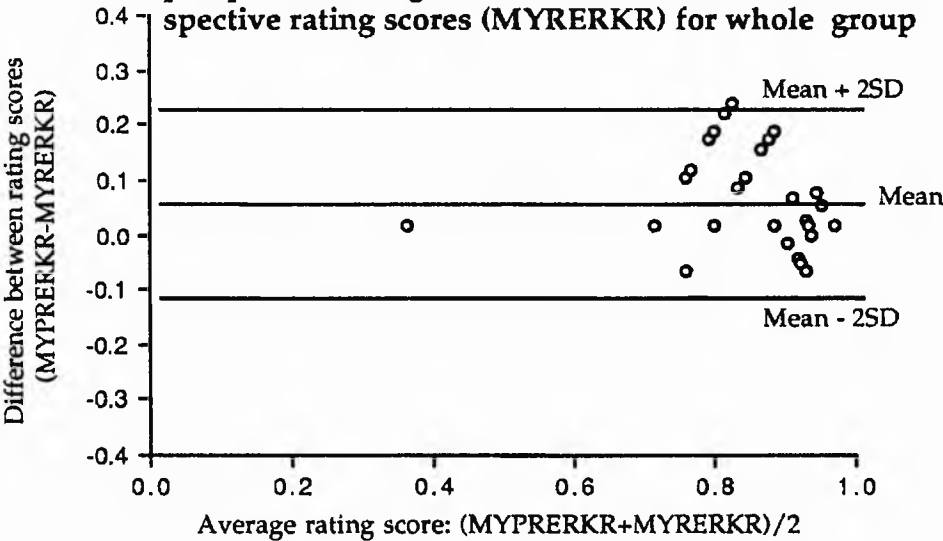
#### (a) Total Control Group

As explained above (page 51), a more appropriate method to decide whether we can use prospective and retrospective rating scores interchangeably would be to test the agreement between the two variables by plotting the difference between them against their mean. Figure 3.7 (page 59) shows a simple scatter diagram of the prospective and retrospective rating scores of the whole control group, with a line of agreement for the two sets of data. Figure 3.8 (page 59) plots the difference between the two sets of data against their mean.

**Fig 3.7: Control Group: Relationship between prospective and retrospective rating scores for whole group**



**Fig. 3.8: Control Group: Test of Agreement between derived prospective rating scores (MYPRERKR) and derived retrospective rating scores (MYRERKR) for whole group**



What is not clear in the diagrams is that for many patients, the difference between the prospective and retrospective rating scores was zero. Unfortunately, many patients overlap at certain points, and only one circle appears in the diagram to represent them.

Figure 3.8 shows no clear relationship between the difference and the mean; the difference between the rating scores neither increases nor decreases

as the average rating score increases. In other words, the Test of Agreement does not display any consistent bias over the range of average rating scores. The mean difference between the prospective and retrospective rating scores was 0.035, with a 95% confidence interval of 0.0077 to 0.0623. Thus, the retrospective rating scores tended to be lower by between 0.0077 and 0.0623. The limits of agreement for the control group data were 0.208 (with a 95% confidence interval of 0.1607 to 0.2553) and -0.138 (with a 95% confidence interval of -0.1853 to -0.0907). The mann-whitney test resulted in an insignificant difference between the medians of the two sets of data (significance level = 0.1979). Before commenting on the acceptability of the limits of agreement, it is important that the same exercise is first carried out on each of the operation site and sex subgroups, so as to obtain a clearer picture of where the main differences lie.

#### (b) Hips

Figure 3.9 (page 61) displays the difference between the prospective and retrospective rating scores against their mean for the patients who had hip joint replacements.

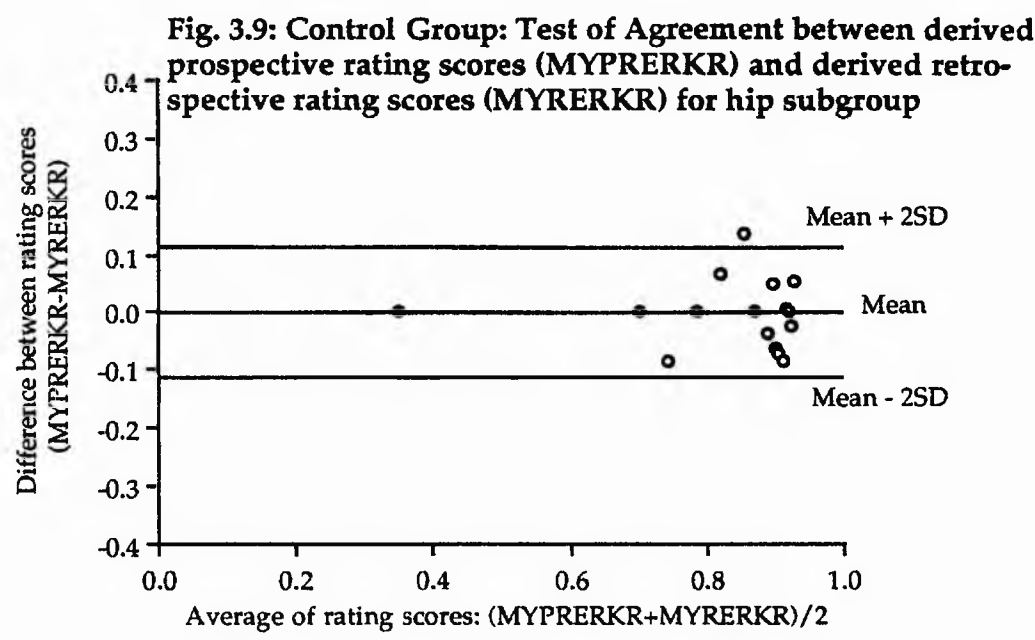
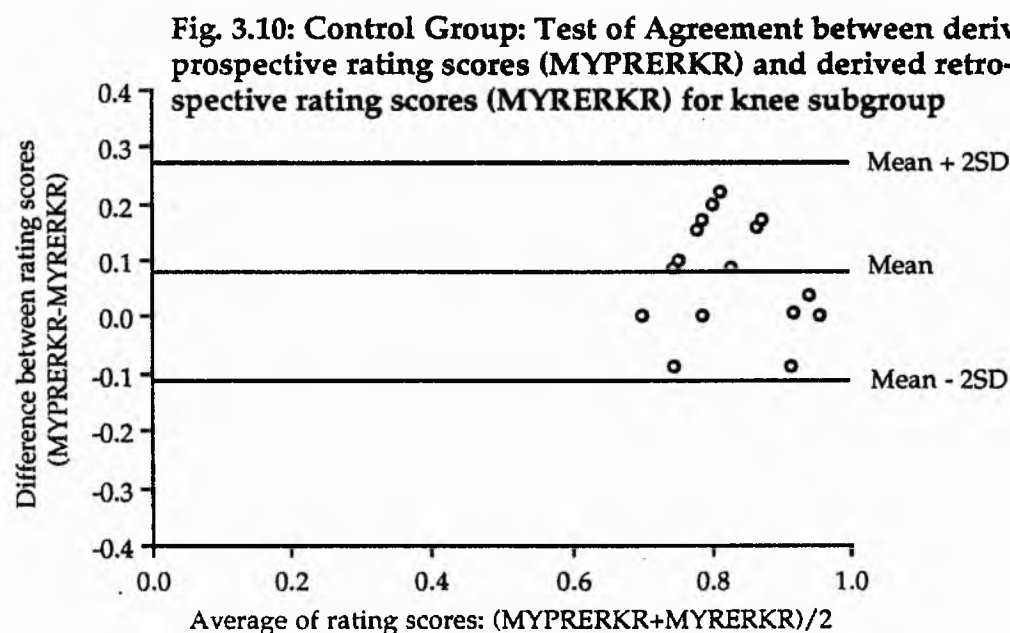


Figure 3.9 displays no consistent bias over the range of average rating scores. In fact, there is very strong agreement between the two sets of scores. Many patients had a mean difference of 0, (though once again they do not all appear because of overlaps). The mean difference between the prospective and retrospective rating scores was -0.003, with a 95% confidence interval of -0.0279 to 0.0220. Hence, in contrast to the control group as a whole, the prospective and retrospective rating scores tended to differ by between -0.0279 to 0.0220. The limits of agreement also are relatively narrow: 0.1094 (with a 95% confidence interval of 0.0661 to 0.1527) and -0.1154 (with a 95% confidence interval of -0.1587 to -0.0721). This is further supported by the very low level of significance (0.8007) for the difference between the medians of the two sets of data.

(c) Knees

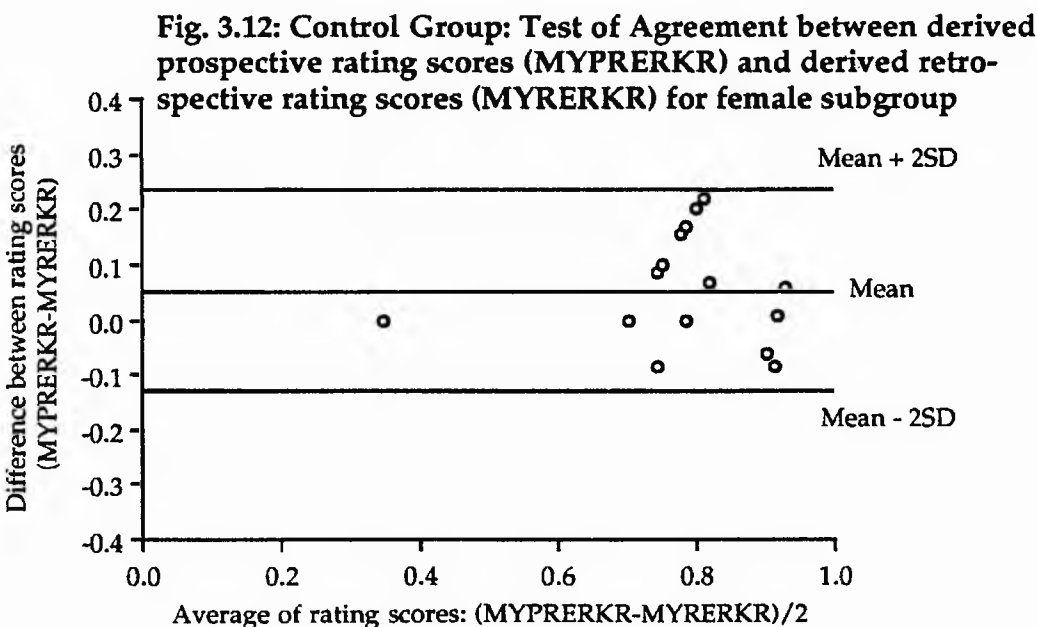
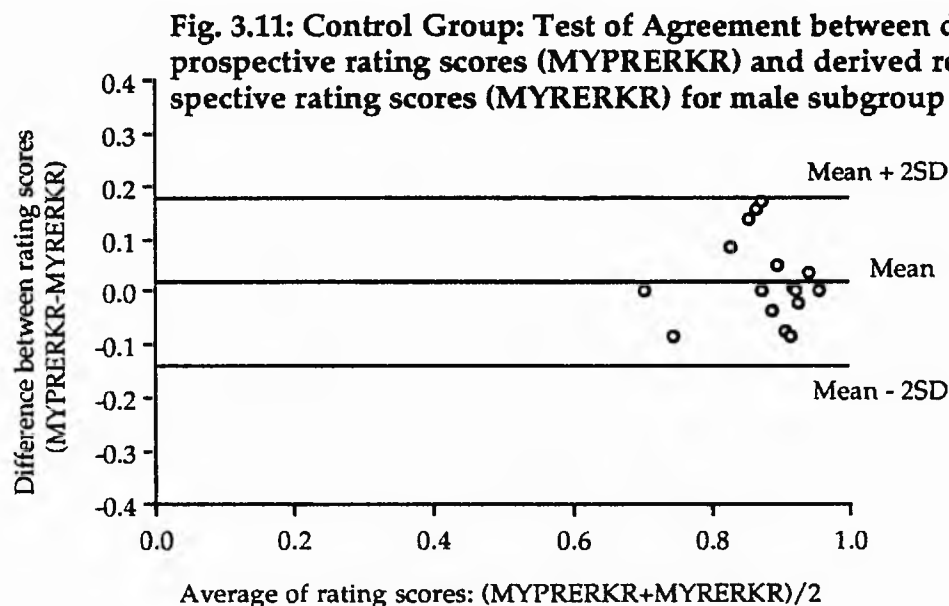
The diagram on page 62 performs the same exercise for the patients who had knee joint replacement surgery.



It is clear in Figure 3.10 that, though there is no consistent bias over the range of average rating scores, the width of the limits of agreement are less acceptable than those of the hip replacement subgroup. The mean difference between the prospective and retrospective rating scores was 0.0789, with a 95% confidence interval of 0.0329 to 0.1250. Thus, the retrospective rating scores tended to be lower by between 0.0329 to 0.1250. The relatively wide intervals for the limits of agreement [0.2699, with a 95% confidence interval of 0.1903 to 0.3495, and -0.1121, with a 95% confidence interval of -0.1917 to -0.0325] reflect the small sample size, and the fact that a small number of outliers have distorted the results of the whole knee replacement subgroup. [Perhaps also a learning effect was at work]. Further evidence of the differences between the two sets of data is provided by the mann-whitney test which calculated a significant difference between the medians of the two sets of data (significance level = 0.0357).

(d) Sexes

Figures 3.11 and 3.12 display the differences between the prospective and retrospective rating scores against their means for the male and female subgroups respectively.



The mean difference between the prospective and retrospective rating scores for the male subgroup was 0.0179, with a 95% confidence interval of -0.0203 to 0.0562. The limits of agreement were 0.1767, with a 95% confidence interval of 0.1103 to 0.2431, and -0.1409, with a 95% confidence interval of -0.2073 to -0.0745. The difference between the medians of the two sets of rating scores was insignificant (significance level = 0.5424). For the males who had hip joint replacements, the mean difference between the prospective and retrospective rating scores was -0.0148, with a 95% confidence interval of -0.0527 to 0.0231, and with limits of agreement of 0.1106 and -0.1402. For the males who had knee joint replacements, the mean difference between the prospective and retrospective rating scores was 0.0890, with a 95% confidence interval of 0.0192 to 0.1588, and with limits of agreement of 0.222 and -0.044.

The mean difference between the prospective and retrospective rating scores for the female subgroup was 0.0497, with a 95% confidence interval of 0.0092 to 0.0902. The limits of agreement were 0.2323, with a 95% confidence interval of 0.1622 to 0.3024, and -0.1329, with a 95% confidence interval of -0.2030 to -0.0628. The significance level of the difference between the medians of the two sets of rating scores was calculated by the mann-whitney test to be 0.0808. For the females who had hip joint replacements, the mean difference between the prospective and retrospective rating scores was 0.0142, with a 95% confidence interval of -0.0187 to 0.0471, and with limits of agreement of 0.0998 and -0.0714. For the females who had knee joint replacements, the mean difference between the prospective and retrospective rating scores was 0.0743, with a 95% confidence interval of 0.0087 to 0.1399, and limits of agreement of 0.2913 and -0.1427.

An analysis of variance performed on the differences between the prospective and retrospective rating scores of the control group patients found that surgery type had a significant effect ( $F=9.71$ ) on the mean difference between the two scores. The sex of the patients had an insignificant



effect ( $F=0.07$ ) on the mean difference between the two scores. This led us to believe that the sex of our group of patients did not have any additional explanatory value for the difference between the prospective and retrospective rating scores. This may not be the case if the study was performed on a much larger sample of patients. However, these results do suggest that, in our study, the difference between the two sets of rating scores is statistically explained by operation type.

It is becoming evident that, based on the information we have obtained from our control group, the use of retrospective data to estimate the health-related quality of life of patients who have had hip replacements, seems acceptable. The mean difference between the prospective and retrospective rating scores for these patients is negligible, and the limits of agreement relatively narrow. Moreover, the patients who had hip replacements neither underestimated nor overestimated their retrospective rating scores. However, when estimating the health-related quality of life of patients who have had knee replacements, we should use retrospective data with caution. The differences within the limits of agreement are wide enough to suggest considerable lack of agreement between prospective and retrospective rating scores. Moreover, the evidence presented above suggests that patients who have had knee replacements consistently underestimate their retrospective rating scores. This suggests that further research is required before any generalisations concerning the acceptability of retrospective data can be made.

#### (e) Total Control Group: Further Test for Bias

It is possible that the level of agreement between the prospective and retrospective rating scores is related to the change in health-related quality of life of the patients who are making the retrospective assessments. In other words, there may be a consistent bias in the retrospective assessments of

patients who have shown the greatest improvements in health-related quality of life following their operations. Alternatively, a bias may exist in the retrospective assessments of patients who have shown the smallest improvements in health-related quality of life following their operations. The following exercise tests the agreement between the prospective and retrospective scores of the whole control group when used as a base to assess health-related quality of life improvements.

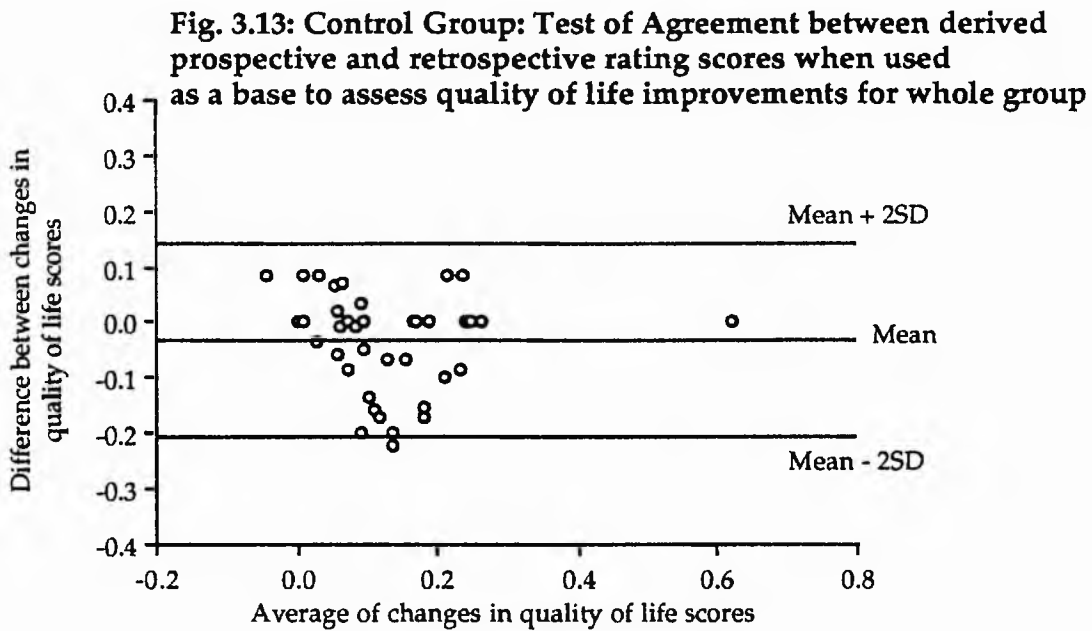
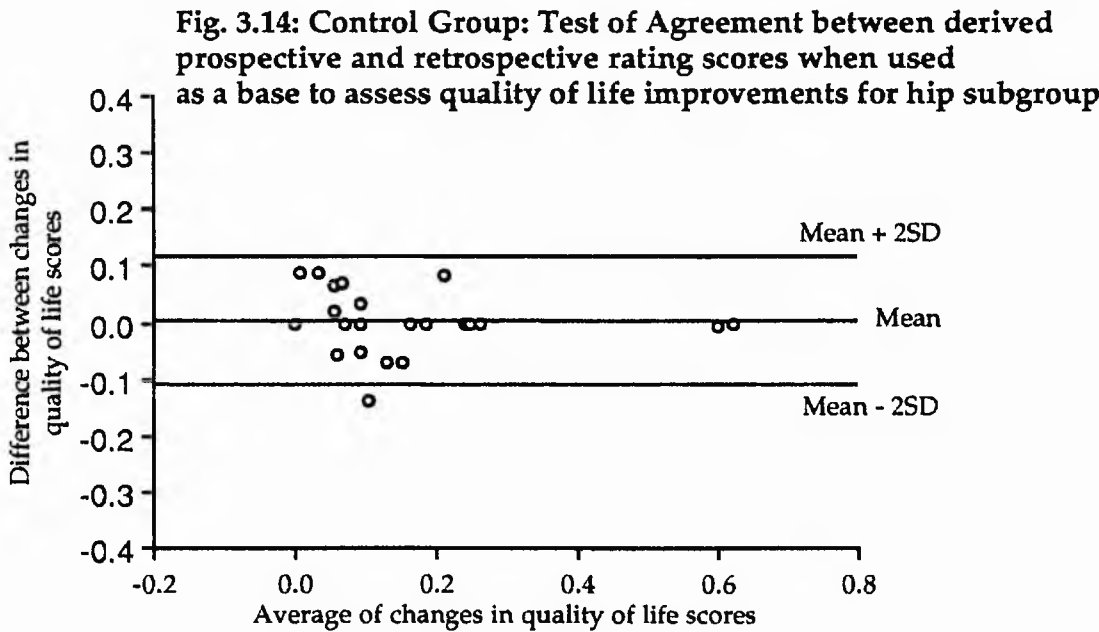


Figure 3.13 displays no consistent bias over the range of average changes in health-related quality of life scores. Amongst patients who achieved little or no change in health-related quality of life, the differences between the changes in health-related quality of life scores were relatively small. In other words, amongst these patients, using either the prospective rating scores or the retrospective rating scores to assess health-related quality of life improvements made little difference. The same seems to be the case for patients who made considerable improvements following their operation. The outliers in the diagram are amongst patients who made moderate

improvements in health-related quality of life. The mean difference between the changes in health-related quality of life scores, when either prospective or retrospective scores are used as a base, was -0.035, with a 95% confidence interval of -0.0823 to 0.0123. Thus, using the retrospective scores as a base tended to lead to slightly higher estimates of health-related quality of life improvements. The limits of agreement were 0.138, with a 95% confidence interval of 0.0907 to 0.1853, and -0.208, with a 95% confidence interval of -0.2553 to -0.1607. Before making any inferences from these results, the results of the same exercise when the control group is broken down into operation site subgroups shall be described.

(f) Hips: Further Test for Bias

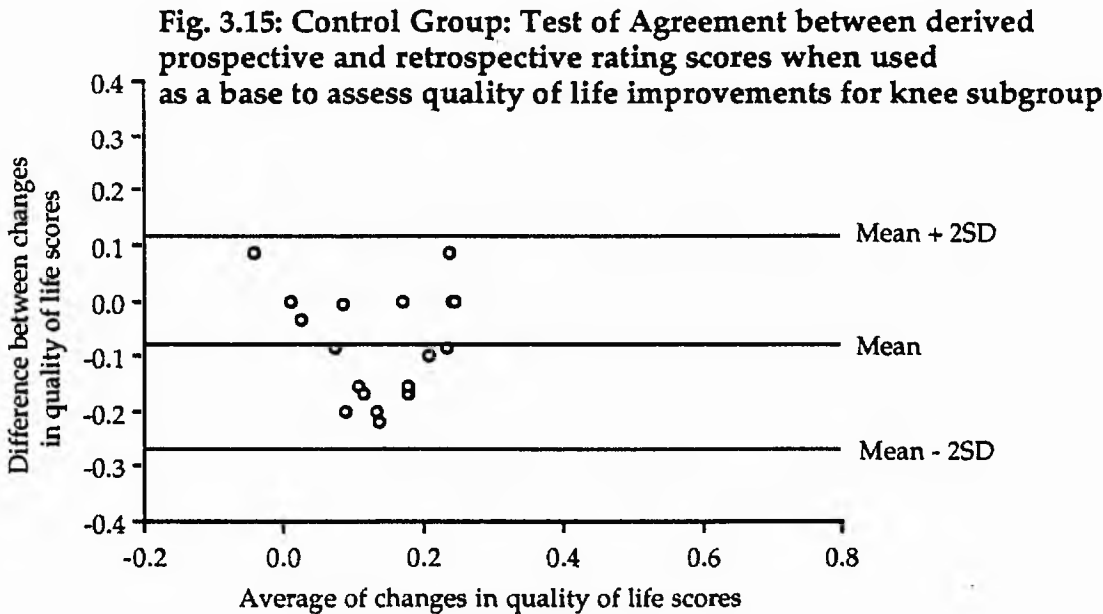
Figure 3.14 tests the agreement between the changes in health-related quality of life scores amongst patients who had hip replacements.



Amongst patients who had hip replacements, there was a smaller bias over the range of average changes in health-related quality of life scores than existed for the control group as a whole. The mean difference between the changes in health-related quality of life scores, when either preoperative or retrospective scores were used as a base, was 0.003, with a 95% confidence interval of -0.022 to 0.0279. Thus, there is no evidence amongst the hip subgroup that using either prospective or retrospective scores, distorts the results unduly. The limits of agreement were relatively narrow: 0.1154, with a 95% confidence interval of 0.0721 to 0.1587, and -0.1094, with a 95% confidence interval of -0.1527 to -0.0661.

(g) Knees: Further Test for Bias

Figure 3.15 illustrates the same test for the knee subgroup.



The diagram confirms our earlier inference that, although there is no consistent bias over the range of average rating scores, the width of the limits

of agreement are less acceptable than those of the hip replacement subgroup. The mean difference between the changes in health-related quality of life scores was  $-0.0789$ , with a 95% confidence interval of  $-0.1250$  to  $-0.0329$ . Thus, using the retrospective score as a base tends to lead to higher estimates of health-related quality of life improvements. A comparison of the results in Figures 3.10 (page 62) and 3.15 (page 68) illustrates how this is largely a result of the lower retrospective rating scores estimated by the knee subgroup. (The bias is not related to the scale of health-related quality of life improvements). The limits of agreement were  $0.1121$ , with a 95% confidence interval of  $0.0324$  to  $0.1917$ , and  $-0.2699$ , with a 95% confidence interval of  $-0.3495$  to  $-0.1903$ .

#### (h) Summary

The two Tests of Agreement described above illustrate a degree of acceptability in using retrospective data when estimating the health-related quality of life of patients who have had hip replacements. For the hip patients in the control group, the mean difference between the prospective and retrospective rating scores was small and the limits of agreement narrow. There was no evidence that the patients either overestimated or underestimated their prospective health-related quality of life scores. Moreover, the level of agreement between the prospective and retrospective rating scores was not related to the scale of change in the health-related quality of life of the patients after their operations. The two Tests of Agreement, however, also illustrate the caution with which retrospective data should be used when estimating the health-related quality of life of patients who have had knee replacements. There was strong evidence that the knee patients in the control group underestimated their preoperative health-related quality of life when making their retrospective assessments. This may have been the result of the relatively small sample size, the

distorting effects of a small group of outliers or even a learning effect. The bias was not related to the scale of change in the health-related quality of life of the patients after their operations. Section 3.331 (page 73) illustrates the differences between prospective and retrospective scores when they are used as the basis for estimating the Cost per QALY gained of knee replacement surgery. The differences between the prospective and retrospective rating scores of the male and female subgroups were shown to be largely the result of the distorting effects of the knee patients. It seems fair to conclude therefore that further research is required before any wider generalisations concerning the acceptability of retrospective data can be made.

### 3.33 Control Group: Quality of Life Improvements

The third aim of the study, and the final one which could be applied to the control group, was to calculate the scale of change in health-related quality of life in patients who have undergone joint replacement surgery, and to elucidate the functions in which the greatest improvements occur. Table 3.3 (page 76) summarizes the various health-related quality of life scores at each stage of the process, and gives a breakdown of the Rosser-Kind ratings into sex/operation site subgroups. As can be seen in the table, there was a marked improvement in the health-related quality of life scores between the preoperative and three month postoperative interviews. For the control group as a whole, the QALY's gained ranged from 0.028 (0.11057/4) to 0.041 (0.16527/4), depending on which estimates are used. Of the 44 patients, the derived estimates showed that 39 improved their rating scores after the three month period, 1 patient's score showed no change, 1 patient's score deteriorated and 3 patients failed to turn up for their follow-up interviews. The respective figures based on the subject's estimates were 36, 2, 3 and 3.

When the data is broken down into hip and knee subgroups, it is immediately noticeable that the improvements in health-related quality of life in the patients who had hip replacements lie in a very narrow range whichever estimates are used. These improvements convert into 0.034-0.036 QALY's gained over the three month period. For the patients who had knee replacements however, the improvements vary between 0.021-0.048 QALY's gained depending on the source and stage of estimation. This is the result of the underestimation of the retrospective scores by the knee subgroup, which was highlighted above. When the data is broken down between the sexes, it is evident that the greatest improvements in health-related quality of life were amongst the female patients. However, this may be because the female subgroup had a lower average prospective rating. At the postoperative stage, the differences between the sexes were not significant. Once again, the divergences in health-related quality of life improvements for each of the sexes were largely the result of the underestimation of the retrospective scores by the knee subgroup.

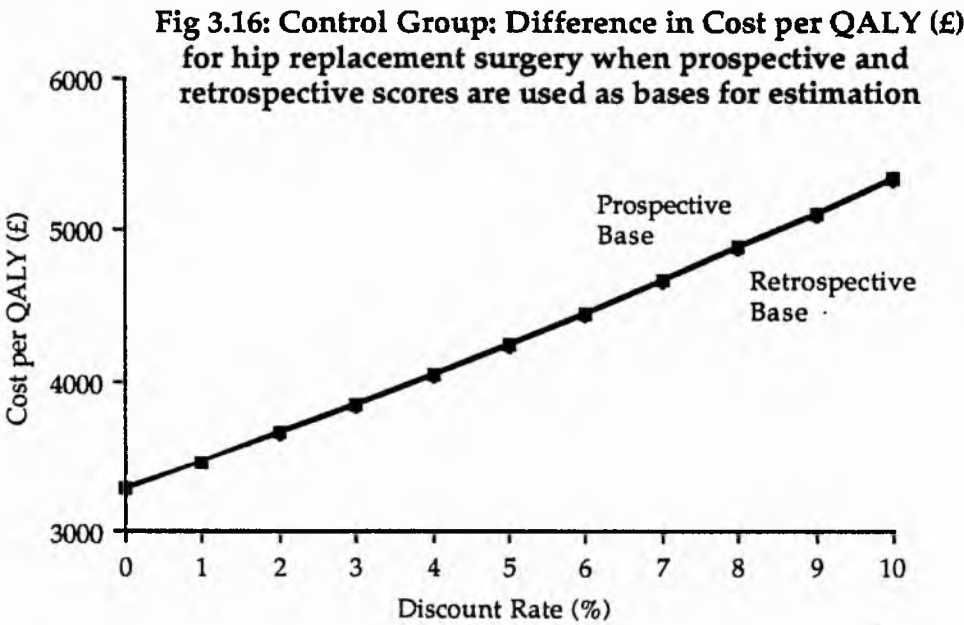
### 3.331 Control Group: Cost per QALY Gained

To illustrate the differences between the prospective and retrospective rating scores of the hip and knee subgroups, the Cost per QALY gained was calculated for hip and knee joint replacement surgery, using both sets of rating scores as the basis for estimation.

#### (a) Hips

Figure 3.16 (page 72) illustrates the exercise for hip replacement surgery. The joint survival period resulting from this type of surgery was assumed to

be 10 years. This estimate lies at the lower range of the results calculated by Kilgus et al. (1991). The derived estimates from the questionnaires were used as the basis of the health-related quality of life information, and the cost of a hip replacement was assumed to be £4,426 (Tayside Health Board, April 1991 prices).



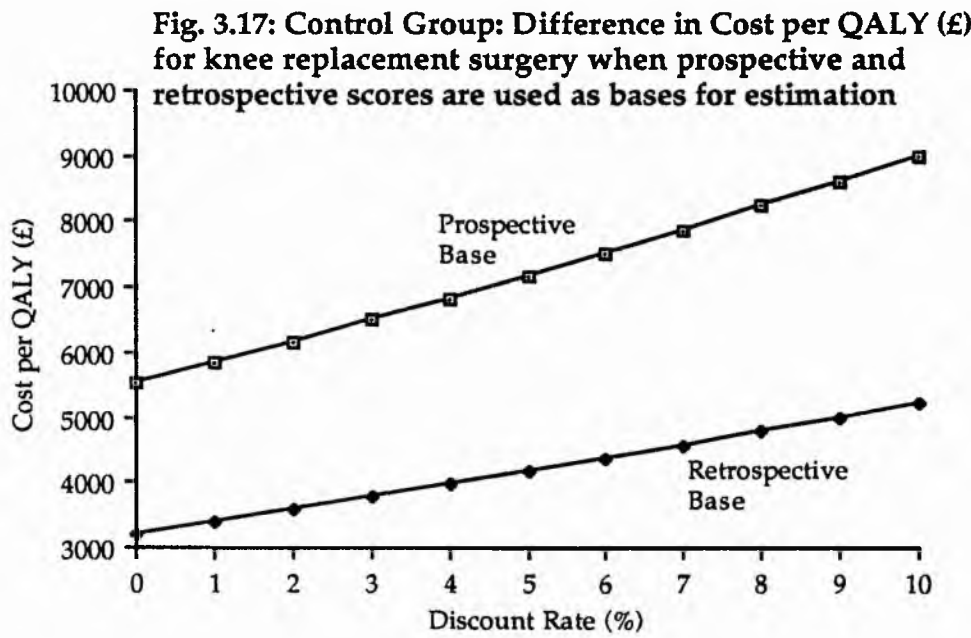
The figure demonstrates that, when a joint survival period of 10 years is assumed, using the two sets of rating scores interchangeably has very little effect on the final Cost per QALY estimate for hip replacement surgery. Indeed, the curves are so close, they are almost indistinguishable. The differences in the Costs per QALY vary between £12 (£3,269 - £3,281) when a discount rate of 0 percent is applied and £19 (£5,320 - £5,339) when a discount rate of 10 percent is applied.

(b) Knees

Figure 3.17 (page 73) illustrates the same exercise for knee replacement surgery. Once again, the survival period of a knee replacement is assumed to



be 10 years [Bowman et al. (1991)], and the derived estimates from the questionnaires are used as the basis of the health-related quality of life information. The cost of a knee replacement is assumed to be £5,302 (Tayside Health Board, April 1991 prices).



The diagram demonstrates quite clearly that there are large differences in the Cost per QALY estimate for knee replacement surgery when prospective and retrospective rating scores are used as the basis for estimating health-related quality of life improvements. Assuming a 0 percent discount rate and a joint survival period of 10 years, the Cost per QALY for knee replacement surgery is £5,531 when prospective rating scores are used as the basis for estimating health-related quality of life improvements, and £3,208 when retrospective rating scores are used as the basis (a difference of £2,323). Assuming a 10 percent discount rate, the respective estimates are £9,002 and £5,221 (a difference of £3,781).

### 3.332 Control Group: Change in Quality of Life for Individual Functions

Appendices 7-11 summarize the change in rating scores for individual questions between the preoperative and postoperative stages. The scales to each question are listed, as are the number of subjects who fall into each category of each scale at the preoperative and postoperative stages. Since we are dealing with interval rather than continuous variables, the chisquare test is used to test the null hypothesis that no improvement in health-related quality of life occur after the operation. Appendix 7 summarizes the results of the whole control group; Appendices 8 and 9 summarize the results of the hip and knee subgroups respectively, and Appendices 10 and 11 summarize the results of the male and female subgroups respectively.

The appendices illustrate significant improvements in the ability to undertake everyday functions. There was an extremely significant reduction in pain (less than the 0.001 level) in every operation site and sex subgroup. In addition, there were significant improvements (at the 0.05 level) in every subgroup in the ability to sleep without noticeable discomfort, in the ability to walk distances without noticeable discomfort, in the ability to bend knees without noticeable discomfort, in the ability to climb stairs without noticeable discomfort and in the ability to sit down on and get up off chairs without noticeable discomfort. The functions in which the improvements were not significant (greater than the 0.1 level) were largely ones in which the subjects already had a high rating prior to their operations (dependence on others for activities of daily living, ability to bathe, ability to dress, ability to cook, assistance in the home and confinement to a chair). The only exceptions were the insignificant improvements in the ability to work and participation in sports. This is hardly surprising, since most patients were elderly and were not employed or active participants in sport prior to their operations. The conclusion here must be that future health status measurements of patients

who have undergone hip and knee joint replacement surgery need not include these functions in their studies, but rather should concentrate on measuring changes within areas where our study has shown significant improvements (pain, sleeping, walking, bending knees, climbing stairs, sitting down on and getting up off chairs).

**Table 3.3 - Control Group: Summary of Rosser-Kind Rating Scores for the Sex and Operation Site Subgroups at the Preoperative, Postoperative and Retrospective Stages**

	Overall Mean RKR	Mean RKR for Males (n=19)	Mean RKR for Females (n=25)	Mean RKR for Hips (n=23)	Mean RKR for Knees (n=21)
SUBPRERKR	0.8475	0.9009	0.8038	0.8267	0.8704
MYPRERKR	0.8368	0.8823	0.8022	0.8246	0.8502
SUBPORKR	0.95807	0.95840	0.95783	0.96220	0.95257
MYPORKR	0.95345	0.95445	0.95255	0.95950	0.94606
SUBRERKR	0.7928	0.8605	0.7419	0.8173	0.7601
MYRERKR	0.8046	0.8643	0.7506	0.8241	0.7808
SUBPORKR-SUBPRERKR	0.11057	0.0575	0.15403	0.1355	0.08217
MYPORKR-MYPRERKR	0.11665	0.07215	0.15035	0.1349	0.09586
SUBPORKR-SUBRERKR	0.16527	0.0979	0.21593	0.1449	0.19247
MYPORKR-MYRERKR	0.14885	0.09015	0.20195	0.1354	0.16526
SUBPRERKR-SUBRERKR	0.0547	0.0404	0.0619	0.0094	0.1103
MYPRERKR-MYRERKR	0.0322	0.018	0.0516	0.0005	0.0694

**Abbreviations :**

MYPRERKR : Derived preoperative Rosser-Kind rating score  
 MYPORKR : Derived postoperative Rosser-Kind rating score  
 MYRERKR : Derived retrospective Rosser-Kind rating score  
 RKR : Rosser-Kind rating score  
 SUBPRERKR : Subject's preoperative Rosser-Kind rating score  
 SUBPORKR : Subject's postoperative Rosser-Kind rating score  
 SUBRERKR : Subject's retrospective Rosser-Kind rating score

### 3.4 Retrospective Group Results

Three main lessons were learnt in our analysis of the control group data. First, the Rosser-Kind Classification of Illness States is an excellent tool of measurement when assessing the health-related quality of life of patients who have had (or are about to have) joint replacement surgery. Second, it seems that we can use retrospective data with some degree of confidence when estimating the improvements in health-related quality of life in patients who have had hip replacements. However, retrospective data should only be used with caution when estimating the improvements in health-related quality of life in patients who have had knee replacements, and further research is required before we can make any wider generalisations concerning the acceptability of retrospective data. Third, there are significant improvements in health-related quality of life following both hip and knee joint replacement surgery. The most significant area of improvement is the reduction in pain and distress.

With these lessons in mind, we can proceed in our analysis of the retrospective group data with the following objectives. First, to compare the use of the Rosser-Kind Classification of Illness States with the questionnaires as methods of assessing the health-related quality of life of the retrospective group patients. Second, to calculate the scale of improvement in health-related quality of life in the retrospective group patients, following their operations. Quality adjusted life years will be used as the method of estimation. The data will then be broken down further, so as to assess the changes within the main functions of everyday life. Third, to use the results to estimate the time period over which the maximum improvements in health-related quality of life are achieved. The most appropriate method of approaching such a study would be to follow up patients who have undergone joint replacement surgery over a period of time following their

operations. However, the time constraints of this study meant that it was not possible, and that retrospective assessments were necessary.

Appendix 12 lists the characteristics of the 159 retrospective group patients. The appendix also tabulates each subject's postoperative Rosser-Kind estimate (rating) of his/her health-related quality of life, the derived postoperative Rosser-Kind estimate (rating) of his/her health-related quality of life, each subject's retrospective Rosser-Kind estimate (rating) of his/her health-related quality of life and the derived retrospective Rosser-Kind estimate (rating) of his/her health-related quality of life. Thus, for each retrospective group patient, four health-related quality of life scores were available for study. Two of the scores were derived from the subject's own positioning on the Rosser-Kind Classification at the postoperative and retrospective stages. The other two were derived estimates of each patient's health-related quality of life at the same stages, based on their answers in the interviews.

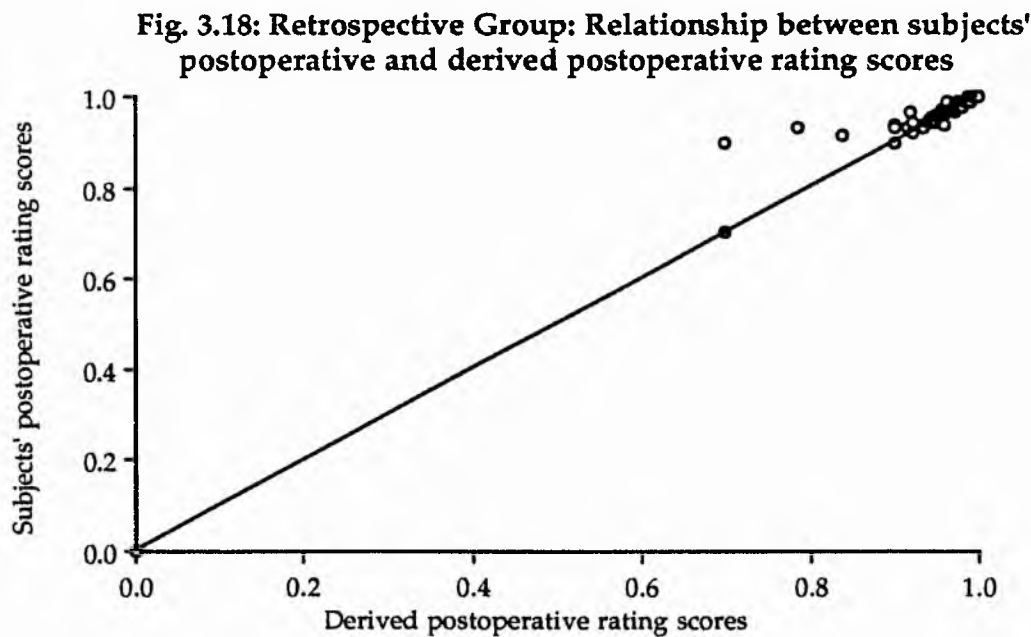
### **3.41 Retrospective Group: Comparison of Rosser Classification with Questionnaires**

The first aim in our analysis of the retrospective group data was to compare the use of the Rosser-Kind Classification of Illness States with the (much more detailed) questionnaires when estimating the health-related quality of life of the retrospective group patients. The correlation coefficients between the patient estimates of their health-related quality of life (based on their positioning on the Rosser-Kind Disability/Distress Scale) and the derived estimates of their health-related quality of life (based on their responses to the questionnaires) were high for both stages: 0.970 at the postoperative stage and 0.971 at the retrospective stage. Moreover, the correlation coefficients between patient estimates and the derived estimates

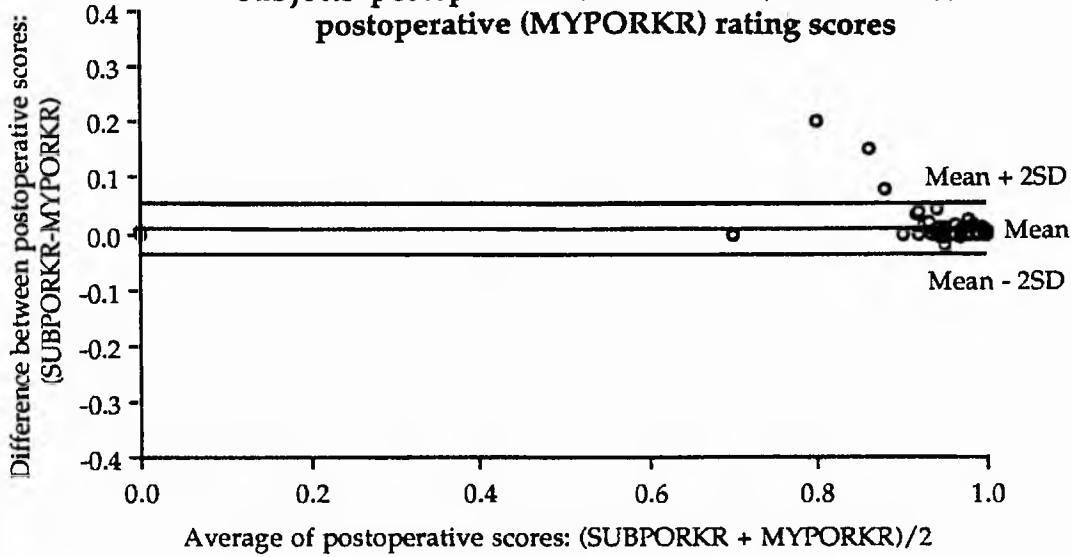
were high in every category of the operation site and sex subgroups. At the postoperative stage, the correlation coefficients were 0.944 for the hip subgroup, 0.816 for the knee subgroup, 0.722 for the male subgroup and 0.979 for the female subgroup. At the retrospective stage, the correlation coefficients were 0.992 for the hip subgroup, 0.840 for the knee subgroup, 0.948 for the male subgroup and 0.988 for the female subgroup. However, as was explained earlier (page 51), a more appropriate method of testing the agreement between two variables is to plot the difference between them against their mean.

(a) Postoperative Stage

Figure 3.18 displays the relation between patient postoperative rating scores and the derived postoperative rating scores, whilst Figure 3.19 (page 80) tests the agreement between the two variables.



**Fig. 3.19: Retrospective Group: Test of Agreement between subjects' postoperative (SUBPORKR) and derived postoperative (MYPORKR) rating scores**

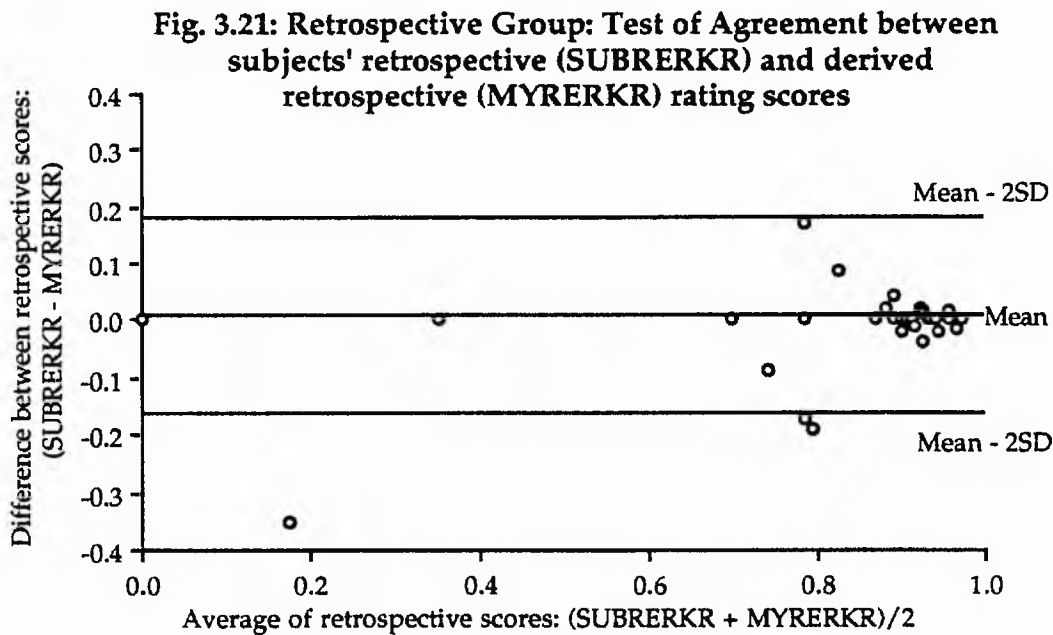
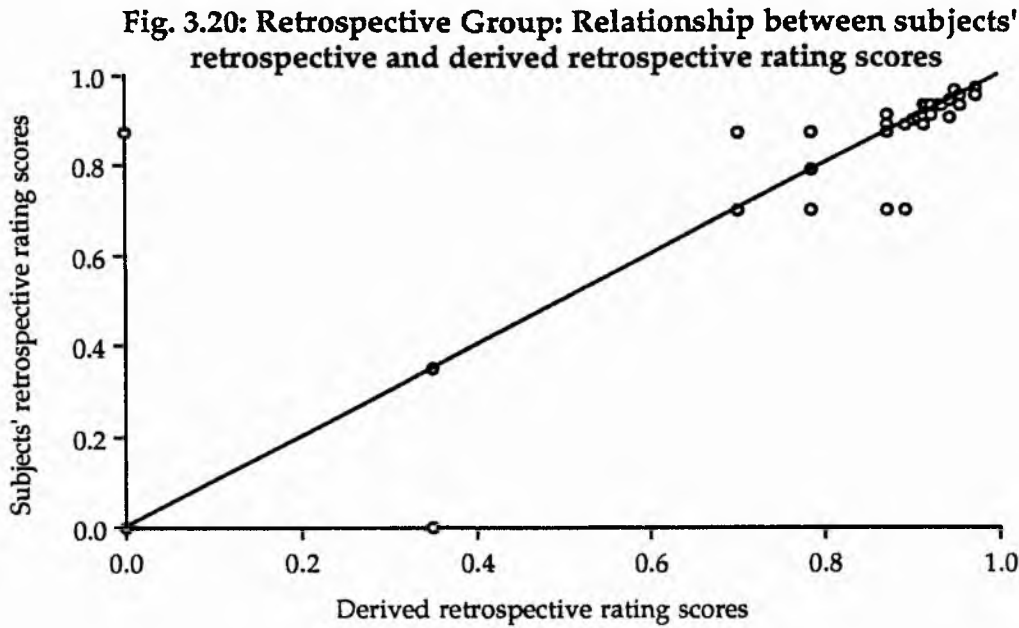


The mean difference between the subjects' postoperative and the derived postoperative rating scores was extremely small, 0.00595, with a 95% confidence interval of 0.00230 to 0.00961. Thus, the derived postoperative rating scores tended to be lower by between 0.00230 and 0.00961. The narrow limits of agreement (0.05093 and -0.03903) and the line of best fit between the two sets of data ( $y = 6.7085e^{-2} + 0.93544x$ ,  $R^2 = 0.942$ ) also suggest that we can confidently use both methods of estimation interchangeably. Furthermore, the difference between the medians of the two sets of postoperative rating scores was insignificant (significance level = 0.2897)

#### (b) Retrospective Stage

Figures 3.20 and 3.21 (page 81) illustrate the same exercise concerning the retrospective rating scores of the retrospective group.





The two diagrams confirm that not only is there strong relation between the patient retrospective rating scores and the derived retrospective rating scores, but there is also strong agreement between the two variables. Most of the patients are clustered very close to the mean difference line, and there is

no consistent bias over the range of average retrospective scores. The mean difference between the subjects' retrospective scores and the derived retrospective scores was 0.00804, with a 95% confidence interval of -0.00602 to 0.02210. The narrow limits of agreement (0.18116, -0.16508) and the line of best fit between the two variables ( $y = 2.6402e^{-2} + 0.97439x$ ,  $R^2 = 0.942$ ) suggest we can use both methods of estimation with confidence. Further support is provided by the mann-whitney test which calculated an insignificant difference between the medians of the two sets of retrospective rating scores (significance level = 0.5587).

### (c) Summary

Table 3.4 (page 83) illustrates the strong agreement between the subjects' estimates of their health-related quality of life and the derived estimates of their health-related quality of life for each of the operation site and retrospective period subgroups.

**Table 3.4: Retrospective Group: Descriptive Statistics Comparing Subjects' and Derived Quality of Life Scores for each Retrospective Period and Operation Site Subgroup**

	Number	Mean	Median	95% Confidence Interval
SUBPOTMH	20	0.95180	0.95025	0.94399-0.95961
MYPOTMH	20	0.94383	0.94550	0.92897-0.95868
SUBPOTMK	10	0.9161	0.9385	0.8584-0.9738
MYPOTMK	10	0.8940	0.9280	0.8188-0.9692
SUBPOOYH	37	0.9359	0.9720	0.8809-0.9909
MYPOOYH	38	0.9276	0.9640	0.8725-0.9826
SUBPOOYK	32	0.96691	0.9640	0.95984-0.97398
MYPOOYK	32	0.95840	0.9620	0.94517-0.97162
SUBPOTYH	48	0.96493	0.9720	0.95199-0.97786
MYPOTYH	58	0.95745	0.9720	0.94312-0.97178
SUBRETMH	20	0.6004	0.7000	0.4288-0.7721
MYRETMH	20	0.6254	0.7000	0.4627-0.7881
SUBRETMK	10	0.7922	0.7850	0.7281-0.8563
MYRETMK	10	0.8007	0.7850	0.7408-0.8606
SUBREOYH	37	0.6485	0.8700	0.4604-0.8365
MYREOYH	38	0.6249	0.7850	0.4398-0.8100
SUBREOYK	32	0.7540	0.8700	0.6596-0.8484
MYREOYK	32	0.7189	0.7850	0.6146-0.8232
SUBRETYH	48	0.8035	0.8700	0.7471-0.8600
MYRETYH	58	0.7898	0.8700	0.7408-0.8389

**Abbreviations :**

MYPO :	Derived mean postoperative Rosser-Kind rating score
MYRE :	Derived mean retrospective Rosser-Kind rating score
SUBPO :	Subjects' mean postoperative Rosser-Kind rating score
SUBRE :	Subjects' mean retrospective Rosser-Kind rating score
TMH :	Three month hip subgroup
TMK :	Three month knee subgroup
OYH :	One year hip subgroup
OYK :	One year knee subgroup
TYH :	Two year hip subgroup

### 3.42 Retrospective Group: Quality of Life Improvements

The two remaining aims of the analysis of the retrospective group data were to estimate the improvements in health-related quality of life in patients who have had hip joint replacements and knee joint replacements, and also to calculate the time period over which the maximum improvements in health-related quality of life are achieved. Table 3.5 (page 90) summarizes the mean Rosser-Kind rating scores at the postoperative and retrospective stages for the entire retrospective group, the operation site and sex subgroups and also the retrospective period subgroups.

It is clear from the table that there were noticeable changes in the health-related quality of life scores for the retrospective group as a whole, and for every subgroup. Nonparametric statistics were used to compare the postoperative health-related quality of life scores of each subgroup because the data was discrete, skewed and indicative of rank order. The medians for each subgroup were as follows: three month hip subgroup (0.95025), one year hip subgroup (0.972), two year hip subgroup (0.972), three month knee subgroup (0.9385) and one year knee subgroup (0.964). The mann-whitney test was used to compare the difference between the sample medians. The medians of the three month and one year hip subgroups were significantly different at the 0.0039 level. The medians of the three month and two year hip subgroups were significantly different at the 0.0014 level. For the one year and two year hip subgroups, the significance level of the difference between the medians was 0.4539. The medians of the three month and one year knee subgroups were significantly different at the 0.005 level.

The average increase in the Rosser-Kind rating score for the 159 patients was between 0.228 and 0.230 (Table 3.5, page 90), depending on the source of estimation, but this figure tells us little since it does not take into account the retrospective periods of estimation. Therefore, it cannot be converted into

average quality adjusted life years gained. Incorporating the time span element allows us to estimate the health-related quality of life improvements at fixed points in time following the operations. The results in Table 3.5 (page 90) are quite interesting. For the knee subgroup, a higher mean Rosser-Kind rating score was calculated for the patients who were interviewed one year following their operations (0.95840-0.96691, depending on the source of estimation) than for the patients who were interviewed three months following their operations (0.8940-0.9161, depending on the source of estimation). If we accept the retrospective estimates as reliable, the average increase in the Rosser-Kind rating scores was between 0.21291 and 0.2395 (equivalent to 0.21291-0.2395 QALY's) for the one year retrospective knee subgroup, compared to an average increase of between 0.0933 and 0.1239 (equivalent to 0.023325-0.030975 QALY's) for the three month retrospective knee subgroup. These results suggest that amongst patients who have undergone knee joint replacement surgery, significant improvements in health-related quality of life are achieved between three months and one year following the operation. In addition, the rate of improvement in health-related quality of life suggests that the highest Rosser-Kind rating score is achieved after the first year.

Amongst the 116 patients who were interviewed following their hip replacements, less consistent improvements are noticeable. The mean Rosser-Kind rating scores were 0.94383-0.95180 for the patients who were interviewed three months after their hip replacements, 0.9276-0.9359 for the patients who were interviewed one year after their hip replacements, and 0.95745-0.96493 for the patients who were interviewed two years after their hip replacements. If we accept the retrospective estimates as reliable, the average increase in the Rosser-Kind rating score was between 0.31843 and 0.3514 for the three month retrospective hip subgroup (equivalent to 0.0796-0.08785 QALY's gained). This compares to an average increase in the Rosser-Kind rating score of between

0.2874 and 0.3027 for the one year retrospective hip subgroup (equivalent to 0.2874-0.3027 QALY's gained), and an average increase of between 0.1614 and 0.1677 for the two year retrospective hip subgroup (equivalent to 0.3229-0.3353 QALY's gained before discounting). These results suggest that for patients who have hip replacements, a higher Rosser-Kind rating score is achieved at three months following the operation than at one year following the operation. It was probably the case that the overall one year retrospective hip sample in Table 3.5 (page 90) included a number of patients with abnormally low rating scores (this is supported by the evidence that the mean rating score of the sample was lower than the median). However, the Rosser-Kind rating score starts to increase again beyond the one year period. The rate of increase in the Rosser-Kind rating score between the first and second year following the operations suggests that the highest rating score is achieved after the second year.

When the retrospective estimates are incorporated into our analysis, it is immediately noticeable that the improvements from the retrospective base decline after the first three months. This is the result of the higher retrospective rating scores estimated by the one year and two year subgroups. It may be the case that the one year and two year subgroups overestimated their preoperative health-related quality of life (these groups of patients may have had greater difficulty in recalling their preoperative health status) and, as a result, the true improvements in health-related quality of life have been underestimated. Alternatively, it may be the case that the patients within these two subgroups were less disabled than the patients in the three month hip subgroup. Our analysis of the control group data found the retrospective estimates at three months to be reliable indicators of the preoperative health-related quality of life of patients who have undergone hip replacement surgery. Whether retrospective assessments at one or two years following an operation are reliable indicators of preoperative health-related quality of life

is beyond the scope of this study. However, the analysis in section 3.5 which matches the control and retrospective groups of patients may go some way in explaining our results.

### **3.421 Retrospective Group: Cost per QALY Gained**

To estimate the QALY's gained over a joint survival period, the health-related quality of life scores for the three month and one year hip and knee retrospective subgroups (using the subjects' estimates) were once again extrapolated over 10 years. Extrapolating the health-related quality of life estimates of the three month hip retrospective subgroup over a 10 year period results in 3.514 QALY's gained (assuming a 0% discount rate), 2.713 QALY's gained (assuming a 5% discount rate) and 2.159 QALY's gained (assuming a 10% discount rate). Extrapolating the health-related quality of life estimates of the one year hip retrospective subgroup over a 10 year period results in 2.874 QALY's gained (assuming a 0% discount rate), 2.219 QALY's gained (assuming a 5% discount rate) and 1.766 QALY's gained (assuming a 10% discount rate). Assuming that the postoperative health-related quality of life score of the three month hip subgroup is achieved immediately after the operation and that the postoperative health-related quality of life score of the one year hip subgroup is achieved immediately after the three month stage results in 3.395 (0% discount rate), 2.621 (5% discount rate) and 2.086 (10% discount rate) QALY's gained respectively over a 10 year period. If it is assumed that the postoperative health-related quality of life score of the three month hip subgroup is not achieved until the three month stage after the operation and that the postoperative health-related quality of life score of the one year hip subgroup is not achieved until the one year stage after the operation, the extrapolated QALY's gained are 2.636, 2.035 and 1.619 respectively over 10

years. Finally, if it is assumed that the postoperative health-related quality of life score of the three month hip subgroup is not achieved until the one and a half month stage after the operation and that the postoperative health-related quality of life score of the one year hip subgroup is not achieved until the seven and a half month stage after the operation, the extrapolated QALY's gained are 3.015, 2.328 and 1.853 respectively over 10 years. As a result of these assumptions, our results suggest 1.619-3.514 QALY's gained over a 10 year period. In terms of the Cost per QALY gained from hip replacement surgery, this is equivalent to £2,734-£1,260, using our earlier cost estimate (£4,426, page 72). Amongst the knee patients, extrapolating the health-related quality of life estimates of the one year retrospective subgroup over a 10 year period results in 2.129 QALY's gained (assuming a 0% discount rate), 1.644 (assuming a 5% discount rate) and 1.308 (assuming a 10% discount rate). This translates into a Cost per QALY for knee replacement surgery of £2,490-£4,054, using our earlier cost estimate (£5,302, page 72).

### **3.422 Retrospective Group: Change in Quality of Life for Individual Functions**

Appendices 13-17 summarize the change in rating scores for individual functions between the retrospective and postoperative stages. The scales to each question are listed, as are the number of subjects who fall into each category of each scale at the retrospective and postoperative stages. Once again, the chisquare test is used to test the null hypothesis that no improvements in health-related quality of life occur after the operation. Appendix 13 summarizes the results of the three month hip subgroup, Appendix 14 the results of the one year hip subgroup and Appendix 15 the results of the two year hip subgroup. Appendices 16 and 17 summarize the results of the two knee subgroups.



Significant improvements in the ability to undertake everyday functions are evident in every subgroup. There were significant improvements (at the 0.05 level) in every subgroup in pain reduction, in the ability to sleep without noticeable discomfort, in the ability to walk distances without noticeable discomfort, in the ability to bend knees without noticeable discomfort, in the ability to climb stairs without noticeable discomfort and in the ability to sit down on and get up off chairs without noticeable discomfort. The chisquare values also reveal some interesting trends. There were consistent improvements over the periods of estimation in all categories apart from the ability to bathe, the ability to cook, assistance in the home and confinement to a chair. This can be accounted for, however, by the high preoperative ratings for these functions. As in our discussion of the control group results, our conclusion is that future health status measurement studies of patients who have undergone hip and knee joint replacement surgery should concentrate on measuring changes within the functions most likely to show improvements (pain, sleeping, walking, bending knees, climbing stairs and sitting down on and getting up off chairs).

**Table 3.5 - Retrospective Group: Summary of Rosser-Kind Rating Scores for each Retrospective Period and Operation Site Subgroup at the Postoperative and Retrospective Stages of Interview**

	SUBPORKR	MYPORKR	SUBRERKR	MYRERKR	SUBPORKR- SUBRERKR	MYPORKR- MYRERKR
TOTAL GROUP	0.95282	0.94465	0.7251	0.7156	0.22772	0.22905
TOTAL HIP GROUP	0.9522	0.94531	0.7102	0.7074	0.2420	0.23791
HIPS: THREE MONTHS	0.95180	0.94383	0.6004	0.6254	0.3514	0.31843
HIPS: ONE YEAR	0.9359	0.9276	0.6485	0.6249	0.2874	0.3027
HIPS: TWO YEARS	0.96493	0.95745	0.8035	0.7898	0.16143	0.16765
TOTAL KNEE GROUP	0.95435	0.94288	0.7616	0.7375	0.19275	0.20538
KNEES: THREE MONTHS	0.9161	0.8940	0.7922	0.8007	0.1239	0.0933
KNEES: ONE YEAR	0.96691	0.95840	0.7540	0.7189	0.21291	0.2395
TOTAL MALE GROUP	0.97227	0.96868	0.7666	0.7518	0.20567	0.21688
TOTAL FEMALE GROUP	0.9432	0.9333	0.7046	0.6985	0.2386	0.2348

**Abbreviations :**

MYPORKR : Derived mean postoperative Rosser-Kind rating score  
 MYRERKR : Derived mean retrospective Rosser-Kind rating score  
 SUBPORKR : Subjects' mean postoperative Rosser-Kind rating score  
 SUBRERKR : Subjects' mean retrospective Rosser-Kind rating score

### 3.5 Matched Control Group and Retrospective Group Patients

In order to compare the results from the control group and retrospective group analyses, the retrospective group patients have been matched to the control group patients in terms of age, sex and operation site. Where possible, the matched patients are of the same sex and are within five years of each other in terms of age at operation. As can be seen in the two appendices (Appendices 18 and 19), an attempt to match each hip patient in the control group to one patient in the three month retrospective hip subgroup, two patients in the one year retrospective hip subgroup and two patients in the two year retrospective hip subgroup has been made (Appendix 18). Likewise, an attempt to match each knee patient in the control group to one patient in the three month retrospective knee subgroup and two patients in the one year retrospective knee subgroup has been made (Appendix 19). The mean Rosser Kind rating scores of the matched patients are shown in Tables 3.6 (page 92) and 3.7 (page 93).

**Table 3.6 : Matched Hips Group: Rosser-Kind Rating Scores of the Hip Patients Matched Between the Control and Retrospective Groups**

Postoperative Period	Control Hip Patients	Retrospective Hip Patients
Three Months	MYPREKR = 0.8246 MYPORKR = 0.95950 MYREKR = 0.8241	MYPORKR = 0.94506 MYREKR = 0.6704
One Year		Sample 1: MYPORKR = 0.9572 MYREKR = 0.597  Sample 2: MYPORKR = 0.9401 MYREKR = 0.7038  Average: MYPORKR = 0.9505 MYREKR = 0.619
Two Years		Sample 1: MYPORKR = 0.97439 MYREKR = 0.8379  Sample 2: MYPORKR = 0.9525 MYREKR = 0.7816  Average: MYPORKR = 0.96343 MYREKR = 0.8098

**Abbreviations :**

MYPREKR : Derived preoperative Rosser-Kind rating score  
 MYPORKR : Derived postoperative Rosser-Kind rating score  
 MYREKR : Derived retrospective Rosser-Kind rating score

**Table 3.7: Matched Knees Group: Rosser-Kind Rating Scores of the Knee Patients Matched Between the Control and Retrospective Groups**

Postoperative Period	Control Knees Patients	Retrospective Knees Patients
Three Months	MYPREKR = 0.8502 MYPORKR = 0.94606 MYRERKR = 0.7808	MYPORKR = 0.8940 MYRERKR = 0.8007
One Year		Sample 1: MYPORKR = 0.95204 MYRERKR = 0.7224  Sample 2: MYPORKR = 0.96645 MYRERKR = 0.6790  Average: MYPORKR = 0.95606 MYRERKR = 0.7303

**Abbreviations :**

MYPREKR : Derived preoperative Rosser-Kind rating score  
 MYPORKR : Derived postoperative Rosser-Kind rating score  
 MYRERKR : Derived retrospective Rosser-Kind rating score

Table 3.6 (page 92) shows that, after the retrospective group patients have been matched to the control group patients in terms of age, sex and operation type, slightly different results are obtained than the overall retrospective group results in Table 3.5 (page 90). Amongst the matched retrospective hip samples, the postoperative Rosser-Kind rating scores increase consistently up until the second year, confirming our earlier inference that the highest rating score is achieved after the second year. Our overall retrospective group result in Table 3.5 (page 90) that amongst patients who have hip replacements, a higher Rosser-Kind rating score is achieved at three months following the operation than at one year following the operation, is not repeated in this analysis. As mentioned above, it was probably the case that the overall one year retrospective hip sample in Table 3.5 (page 90) included a number of patients with abnormally low rating scores (this is supported by the evidence

that the mean rating score of the sample was lower than the median). Further evidence is provided by the mann-whitney test between the matched three month hip sample and the average matched one year hip sample. This test found the difference between the medians of these two samples (0.951 and 0.9659 respectively) were significantly different at the 0.0363 level. After the patients have been matched therefore, the evidence indicates a continuous increase in the Rosser-Kind rating score up until and beyond the second year.

Using the mann-whitney test, there were no significant differences between the median retrospective rating score of the control group hip patients and the median retrospective rating scores of the matched sample patients. The significance levels between the median retrospective rating scores of the control group hip patients and the matched three month, one year and two year samples were 0.1297, 0.1226 and 0.6662 respectively.

Table 3.7 (page 93) confirms our earlier conclusion that amongst patients who have undergone knee joint replacement surgery, significant improvements in health-related quality of life are achieved between three months and one year following the operation, and that the highest Rosser-Kind rating score is achieved after the first year. The median postoperative rating scores of the matched three month and matched one year knee samples (0.928 and 0.9595 respectively) were significantly different at the 0.0679 level. Further, the retrospective estimate of the knee control group was not statistically different from those of the matched retrospective groups at three months (0.5059 significance level) and at one year (0.8994 significance level). This evidence increases the validity of the use of retrospective estimates.

## CHAPTER 4

### SENSITIVITY ANALYSIS OF GUDEX STUDY

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## 4.1 Introduction

In this chapter, the attempt by Gudex (1986) to use cost per quality adjusted life year (QALY) data as a means of determining the efficient allocation of health service resources is analysed. This study was selected for analysis in recognition of the fact that it was an early attempt to open up the debate on the application of cost utility analysis to health care. The chapter does not discuss the theoretical assumptions underlying QALY's, but rather works within a debatable framework and discusses the problems involved in calculating and applying QALY's. Specifically, this involves analysing the sensitivity of Gudex's cost utility calculations to her underlying assumptions. In the first section, Gudex's main arguments are outlined. This is followed by a discussion of the underlying assumptions of the study. The main body of the chapter then presents an extensive sensitivity analysis of those underlying assumptions and will allow us to gauge the confidence with which we can use Gudex's results. Finally, some conclusions are offered.

## 4.2 Summary of Gudex Study

Gudex (1986) incorporates quality-adjusted life-years (QALY's) into Cost per QALY data in an attempt to formulate efficient criteria when allocating health service resources. Using seven medical programmes as examples, she illustrates how both costs and health outcomes should be taken into account when determining priorities in the competition for finite resources. The seven medical programmes which Gudex focuses on are CAPD, haemodialysis, the treatment of cystic fibrosis with ceftazidime, kidney transplants, shoulder joint replacements, scoliosis surgery for idiopathic adolescents and scoliosis surgery for neuromuscular illness.



QALY's are used as the proxy measure of health outcome and are calculated using both health-related quality of life estimates and survival data. Gudex obtained the health-related quality of life estimates by converting the information in the available medical literature into the 'Classification of Illness States', developed by Rosser and Kind (1978) and Kind et al. (1982). The health-related quality of life estimates for each medical condition were then multiplied by ranges of potential survival periods which had been discounted by 5% to reflect the subjects' positive marginal rate of time preference. Hence, ranges of QALY's were obtained for each of the seven medical procedures. In this way, it is argued, the relative benefits of each of the medical procedures could be combined with their relevant costs to formulate efficient resource allocation decisions.

### 4.3 Assumptions Underlying Gudex Study

The first major assumption of the study is that the information on patient outcome for each of the seven medical conditions has been accurately converted into the Classification of Illness States, that is Gudex assumes that she has accurately converted the parameters most easily comparable to the disability and distress dimensions of the Rosser Classification. A discussion of the acceptability of the conversions of the outcome parameters in each of the medical studies follows in the next section, together with an extensive sensitivity analysis of those conversions.

A second assumption that Gudex makes is that the subjects analysed in each study are representative of all patients undergoing those medical procedures. However, as a result of the paucity of adequate outcome data available for the seven medical procedures under study, the papers selected as a basis for analysis do not all represent the diversity of characteristics present

in the populations with their respective conditions. The study by Evans et al. (1985), for example, which was used to assess the health-related quality of life of patients with end-stage renal failure was (according to the authors themselves) "...limited by both the nonrepresentativeness and the size of the sample of centers and patients studied" (page 557). The 27 patients in the study by Boyle et al. (1976), who formed the basis of the health-related quality of life assessments of cystic fibrosis patients, had an average age of just under 20 years. This contrasts with a median age at death of British cystic fibrosis patients of 17 years in 1986 [Britton (1989)], the year that the Gudex study was formulated. The diagnoses in the study by Collis and Ponseti (1969), which Gudex uses to assess the health-related quality of life of untreated scoliotics, have been questioned by Dickson (1983). In addition, the assumption Collis and Ponseti (1969) make concerning the death rate of untreated scoliotics is at variance with the finding of Nilssonne and Lundgren (1968) whose follow-up period was 20 years longer. It seems therefore that, in selecting sources of information on patient outcomes that are comparable to the Rosser Classification, Gudex may have unwittingly used studies which are not representative of their wider clinical populations.

A third assumption of the Gudex study is that the improved health-related quality of life scores attained by patient groups who have undergone surgery or treatment remain constant and do not deteriorate over the duration of their extended lives or the stated duration of improvement. However, it is likely that for some of the medical conditions studied, the health-related quality of life scores will deteriorate over that period. For patients who have had shoulder joint replacements, for example, the high incidence of loosening after 5 years is likely to have an adverse effect on the postoperative health-related quality of life scores. This in turn is likely to reduce the relative cost effectiveness of shoulder joint replacement surgery.

A fourth assumption that Gudex makes is that the Classification of Illness States encompasses all the factors that are relevant to the health-related quality of life of all the patient groups. However, as a result of its generic nature, it has a tendency to include certain factors that are irrelevant to some patient groups (the emphasis on employment, for example, with respect to elderly patients) and exclude other factors which may arguably contribute to one's quality of life (for example, job satisfaction).

Implicit within the Rosser Classification are a number of assumptions. It is assumed the health state valuations have been derived from the correct number and combination of subjects. The group of 70 subjects used to derive the valuations however may be unrepresentative of the general population. It is assumed that health status can accurately be measured. This does not allow for the fact that difficulties arise when accurately defining health states and when ascribing proportionate values to those health states. It is assumed that the subjects were both knowledgeable and well informed when assigning preference values to the alternative health states. In reality, members of the general public often require advice from medically-qualified personnel [Mooney (1986)]. It is assumed that the patients amongst the 70 subjects, whose preferences form the basis of the Classification, valued the health states honestly. This overlooks the possible self-interest the patients may have felt in exaggerating their own level of health status [Drummond (1981)]. A similar tendency to magnify the scale of a problem may have been the result of subjects expressing altruistic concern for a particular illness. It is assumed the 70 subjects responded rationally when rating the health states. It is assumed that the interview method used in the development of the Classification has no bias on the results. In fact, the subjects' responses may have been influenced by the exact wording of the health state descriptions [Bulpitt and Fletcher (1990)]. Another possibility is that the subjects may not have been expressing their true preferences but rather what they thought

were the 'right answers' [Thompson et al. (1984)]. Finally, it is assumed that the ratio scaling method used to develop the scale is the most appropriate method for measuring health state preferences.

The fifth assumption of the Gudex study is that information from studies which were performed at different times and in different places can be compared in the same league table. Gudex's league table compares converted information from the British and overseas medical literature, which covered a 17 year time span (1968-1985). As shall be discussed in more detail in Chapter 7, it is a methodological error to compare the results from studies which were performed at different places and in different years.

The sixth major assumption in the Gudex study is that all the appropriate and relevant costs have been taken into account in the cost utility calculations. However, we are not told which costs are included in the calculations (for example, whether indirect costs are included).

The final assumption of the Gudex study is that future costs and benefits should be discounted at a rate of 5% to reflect the subjects' positive marginal rate of time preference. A discussion of the acceptability of this assumption will follow in the next section of this chapter.

#### **4.4 Sensitivity Analysis of Gudex Study**

In this section, the assumptions which underlie Gudex's estimates of the benefits which accrue from each medical programme will be varied over a range of possible values. If, as a result of our sensitivity analyses the basic conclusions of the study remain unchanged, then the confidence with which we can use Gudex's cost utility estimates will increase. If, however, those conclusions are shown to be sensitive to reasonable variations in the

assumptions, then doubts will be raised over the overall conclusions of the study.

Since the benefits of each medical programme are calculated by multiplying health-related quality of life estimates by ranges of potential survival periods which have been discounted by 5%, an alteration in any of these three variables (the health-related quality of life score, the survival period and the discount rate) may affect the QALY and Cost per QALY estimates. Sensitivity analyses will be performed on Gudex's assumptions about these three variables for each of the seven medical procedures. First, sensitivity analyses will be performed on Gudex's health-related quality of life and survival estimates for each of the seven medical procedures. This will be followed by a sensitivity analysis performed on the 5% discount rate.

#### **4.41 Sensitivity Analysis of Quality of Life and Survival Estimates**

##### **(a) CAPD**

Gudex estimates the health-related quality of life of patients receiving continuous ambulatory peritoneal dialysis (CAPD) by converting the information about 81 patients in the study by Evans et al. (1985) into the Rosser Classification. These 81 patients were assessed by Evans et al. (1985) according to the Karnofsky Index [Karnofsky and Burchenal (1949)] and, though it is not stated explicitly, it seems that Gudex ascribes categories from the Karnofsky Index into the Rosser Classification as follows:

**Table 4.1: Gudex's Conversion of the Karnofsky Index Categories into the Rosser-Kind Classification**

Karnofsky Categories	Number of Patients	Rosser Disability Categories	Rosser Distress Categories
No complaints; almost normal physical activity (A)	39	I-II	A
Able to carry out normal physical activity at least part of the time (B)	20	III	A
Only able to carry out physical activity involving self-care (C)	10	IV	B
Requires at least some assistance for care of bodily needs; may require special care; often debilitated (D)	12	V-VI	C
Requires institutionalization or hospitalization; may be moribund (E)	0	VII-VIII	D

Gudex then multiplied the proportion of the 81 patients in each Rosser Disability/Distress Category by the valuation for that category. In this way, she obtained a health-related quality of life score of 0.96 for patients receiving CAPD. In her final cost utility calculations, she assumes a survival period of 4 years, resulting in an estimate of 3.4 QALY's gained per patient (after discounting). With an annual cost per patient of £12,866 (1986 prices), Gudex's final Cost per QALY estimate per patient is £13,434.

Appendix 20 summarizes a sensitivity analysis of Gudex's conversion of the Karnofsky Categories into Rosser Disability/Distress Categories. The Appendix illustrates the robustness of Gudex's Cost per QALY estimate for CAPD, despite a rigorous testing of the effects of alternative conversions. The Cost per QALY estimates in the sensitivity analysis of 14 alternative, reasonable scenarios fluctuate over a very narrow range (£13,110-£14,499). This compares favourably to Gudex's estimate of £13,434. In addition, the sensitivity analysis of potential survival periods has little effect on the Cost per QALY estimates, since the increased cost of treatment and annual QALY's

gained per patient tend to cancel each other out. The table below illustrates the insensitivity of Gudex's Cost per QALY estimate for CAPD; the sensitivity analysis has no effect on her cost utility rankings of the seven medical procedures.

**Table 4.2: Gudex's Cost Utility Rankings after Sensitivity Analysis of CAPD Data**

Procedure	Cost per QALY
CAPD	£13,110-£14,499
Haemodialysis	£9,075
Treatment of cystic fibrosis with ceftazidime	£8,225
Scoliosis surgery - idiopathic adolescent	£2,619
Kidney transplant	£1,413
Shoulder joint replacement	£592
Scoliosis surgery - neuromuscular illness	£194

(b) Haemodialysis

Gudex estimates the health-related quality of life of patients receiving haemodialysis by converting the information available in three medical studies [Bonney et al. (1978), Evans et al. (1985) and Procci (1980)] into the Rosser Classification. The first two of these studies provided information on the health-related quality of life of patients on both home and hospital haemodialysis, whilst the third study only provided information on the health-related quality of life of patients on hospital haemodialysis. In her final cost utility calculations, Gudex uses the information in the study by Procci (1980) to estimate a health-related quality of life score of 0.94. Assuming a survival period of 8 years, an estimate of 6.1 QALY's gained per patient is

arrived at (after discounting). With an annual cost per patient of £8,569 (1986 prices), Gudex's final Cost per QALY estimate per patient is £9,075.

Gudex arrives at a health-related quality of life score of 0.94 for patients on hospital haemodialysis by making two sets of conversions of the Procci data. The first set of conversions Gudex makes is from the Ruesch Disability Scores [Ruesch et al. (1972)], used by Procci to estimate the disability of 16 patients, into Rosser Disability Categories. The Disability Scores are categorised as follows:

**Table 4.3: Gudex's Conversion of the Ruesch Disability Scores into Rosser Disability Categories**

Ruesch Disability Score		Number of Patients	Rosser Disability Category
0-20	No Social Disability	0	I
20-49	Minor Social Disability: can continue as usual with home or occupational activities	6	II
50-79	Major Social Disability: must alter work programme, if patient can work at all, rely on regular outside help	10	III-V
80-109	Total Social Disability: 24 hour full care or in an institution	0	VI-VIII

The second set of conversions Gudex makes is from the Social Modifiers within the Ruesch Disability Scores, which "reflect the impact that physical or behavioral impairment has upon the patient's life" [Gudex (1986); page 27] into Rosser Distress Categories. Gudex categorises the Social Modifiers as follows (but without any explanation of how this categorisation was decided):



**Table 4.4: Gudex's Conversion of the Social Modifiers within the Ruesch Disability Scores into Rosser Distress Categories**

Social Modifier Score	Number of Patients	Rosser Distress Category
1-5	0	A
6-19	11	B
20-39	3	C
40-55	2	D

Appendix 21 summarizes an extensive sensitivity analysis of the two sets of conversions Gudex makes of the Procci data; 40 alternative sets of assumptions are presented. Alternative conversions of the Disability Scores and Social Modifier Scores into Rosser Disability / Distress Categories have little effect on the final Cost per QALY estimate for haemodialysis. Indeed, the Cost per QALY estimate only varies between £8,741 and £9,656 as a result of the sensitivity analysis, compared to Gudex's estimate of £9,075. In addition, a sensitivity analysis of the potential survival periods of between 2 and 10 years only leads to a small variation in the Cost per QALY estimate (less than £30). This is the result of the recurring annual costs for haemodialysis counterbalancing the annual QALY's gained per patient. The table below illustrates how the sensitivity analyses do not alter Gudex's cost utility rankings for the seven medical procedures:

**Table 4.5: Gudex's Cost Utility Rankings after Sensitivity Analysis of Haemodialysis Data**

Procedure	Cost per QALY
CAPD	£13,434
Haemodialysis	£8,741 -£9,656
Treatment of cystic fibrosis with ceftazidime	£8,225
Scoliosis surgery - idiopathic adolescent	£2,619
Kidney transplant	£1,413
Shoulder joint replacement	£592
Scoliosis surgery - neuromuscular illness	£194

Gudex also estimates the health-related quality of life of patients receiving haemodialysis by converting the information about 634 patients in the study by Evans et al. (1985) into the Rosser Classification. By ascribing categories from the Karnofsky Index into the Rosser Classification (as described on page 102), she estimates a health-related quality of life score of 0.97 for the 287 patients treated with home haemodialysis and a health-related quality of life score of 0.95 for the 347 patients treated with hospital haemodialysis. These health-related quality of life scores are tabulated in the main body of the paper, but do not affect the final cost utility estimate of haemodialysis treatment (which Gudex bases on the conversions from the Procci study).

Appendix 22 summarizes a sensitivity analysis of Gudex's conversion of the Karnofsky Categories into Rosser Disability/Distress Categories; fourteen alternative scenarios are presented. As in Appendix 21, the sensitivity analysis illustrates the robustness of Gudex's cost utility estimate for haemodialysis treatment. The Cost per QALY estimates vary between £8,659 and £9,114 for home haemodialysis treatment, and between £8,833 and £9,855 for hospital haemodialysis treatment. This compares to Gudex's estimate of £9,075 for 'haemodialysis' treatment. As in Appendix 21, the sensitivity analysis of potential survival periods has little effect on the Cost per QALY estimates, and Gudex's cost utility rankings of the seven medical procedures is not affected by the exercise.

#### (c) Renal Transplant

Gudex estimates the health-related quality of life of patients undergoing kidney transplantation by converting the information available in two medical studies [Procci (1980), Evans et al. (1984)] into the Rosser Classification. In her final cost utility calculations, Gudex uses the

information in the study by Procci (1980) to estimate a health-related quality of life score of 0.96. With the additional assumptions of a 10 year survival period and a total one-off cost per patient of £10,452 (1986 prices), the final Cost per QALY estimate arrived at is £1,413.

Gudex arrives at a health-related quality of life score of 0.96 for patients undergoing kidney transplantation by making two sets of conversions of the Procci data for 16 patients into the Rosser Classification (the conversions are explained on pages 104-105). Appendix 23 tabulates the sensitivity of Gudex's Cost per QALY estimate to alternative conversions of the Procci data into the Rosser Classification. The sensitivity analysis presents 40 alternative and reasonable sets of conversions into the Rosser Classification. The results that emerge in the Appendix are quite interesting. For given potential survival periods, alternative conversions into the Rosser Categories make little difference to the final Cost per QALY estimate. This may be explained by the fact that renal transplantation is a procedure in which quality adjustment makes almost no difference. If we assume a potential survival period of 10 years, for example, the alternative conversions into the Rosser Categories only lead to a £43 difference in the Cost per QALY estimates (£1,381-£1,424). However, a sensitivity analysis of the potential survival periods leads to a wide variation in the Cost per QALY estimates. This is the result of the one-off cost for a kidney transplant reducing the average annual cost per patient as the potential survival period increases. The table below illustrates how the assumption of a four year survival period reduces the cost effectiveness of kidney transplantation, and alters Gudex's cost utility rankings for the seven medical procedures (the pre-sensitivity analysis rankings are shown in brackets):

**Table 4.6: Gudex's Cost Utility Rankings after Sensitivity Analysis of Kidney Transplant Data**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Treatment of cystic fibrosis with ceftazidime	£8,225 (3)
Kidney transplant	£3,003-£3,101 (5)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

A sensitivity analysis was also carried out on Gudex's conversion of the Evans data into the Rosser Classification. Evans et al. (1984) had assessed 144 patients, who had undergone kidney transplantation, according to the Karnofsky Index. Gudex ascribed categories from the Karnofsky Index into the Rosser Classification according to the procedure described previously (page 102). Appendix 24 tabulates the sensitivity analysis of Gudex's conversion of the Karnofsky Categories into Rosser Disability/Distress Categories. In the Appendix, 14 alternative sets of conversions into the Rosser Classification are presented. As in Appendix 23, for given survival periods, alternative conversions of the Karnofsky Categories into Rosser Disability/Distress Categories have little effect on the Cost per QALY estimate for kidney transplantation. However, reducing the potential survival periods also reduces the cost effectiveness of kidney transplantation. Assuming a survival period of 4 years, for example, alters Gudex's cost utility rankings of the seven medical procedures (Table 4.6).

#### (d) Upper Limb Joint Replacement Surgery

Gudex estimates the health-related quality of life of patients undergoing shoulder joint replacement surgery by converting the patient outcome data in three medical studies [Clayton et al. (1982), Cofield (1984) and Neer et al. (1982)] into the Rosser Classification. Of these three studies, her final cost utility estimate is based on the conversions of the outcome data of 29 shoulder replacements evaluated by Cofield (1984). This author had evaluated 29 shoulder replacements in patients with rheumatoid arthritis, 31 shoulder replacements in patients with osteoarthritis and 13 shoulder replacements in patients with post-traumatic arthritis. Gudex graded the preoperative health-related quality of life of the patients in Rosser Categories IV-VC-D since all the patients suffered either moderate or severe pain and the range of motion of their shoulder joints was significantly impaired. She also estimated the postoperative health-related quality of life of the patients by categorising their success in an exercise programme into the Rosser Classification as follows:

**Table 4.7: Gudex's Conversion of Cofield's Exercise Programme Categories into the Rosser-Kind Classification**

Cofield's Exercise Programme Categories	Number of Shoulders	Rosser Categories
<b>A:</b> Excellent: No or slight pain, patient satisfied. Full use of shoulder. Muscle strength near normal. Able to do usual work and strenuous activity, eg, tennis, golf.	6	IA
<b>B:</b> Satisfactory: Slight or moderate pain only with vigorous activity. Patient satisfied, good use of shoulder for full daily function, minimum of 30% normal muscle strength.	11	II-III B
<b>C:</b> Unsatisfactory: Above criteria not met.	7	IV-VC-D
<b>D:</b> Limited Goals Rehabilitation. Successful: No, slight or moderate pain only with vigorous activity.	3	IV B
<b>E:</b> Limited Goals Rehabilitation. Unsuccessful: Above criteria not met.	2	VD

By multiplying the proportion of the patients who fell into each Rosser Disability/Distress Category by the valuation for that category, Gudex obtained a postoperative health-related quality of life score of 0.93 for the patients suffering from rheumatoid arthritis, a postoperative health-related quality of life score of 0.96 for the patients suffering from osteoarthritis and a postoperative health-related quality of life score of 0.95 for the patients suffering from post-traumatic arthritis.

Her final cost utility calculations are based on the health-related quality of life of the osteoarthritis patients. Assuming a joint survival period of 10 years and a total one-off cost of £533 (1986 prices) for a shoulder joint replacement, a final Cost per QALY estimate of £592 is attained (after discounting).

Appendix 25 summarizes the effects of alternative and reasonable assumptions concerning the preoperative health-related quality of life of shoulder joint replacement patients, the categorisation of the full exercise programme categories into Rosser Categories and the joint replacement

durations, on the final Cost per QALY estimate. The Appendix is split into three sections which tabulate the sensitivity analyses of the outcome data for the rheumatoid arthritis, osteoarthritis and post-traumatic arthritis groups respectively.

The Appendix illustrates the sensitivity of Gudex's Cost per QALY estimate to her assumptions. Amongst the rheumatoid arthritis group, when a joint replacement duration of 10 years is assumed, 59 of the 160 examples of the sensitivity analysis result in Cost per QALY estimates which are large enough to alter Gudex's cost utility rankings of the seven medical procedures. When a joint replacement duration of 8 years is assumed, 68 of the 160 examples of the sensitivity analysis result in Cost per QALY estimates which are large enough to alter Gudex's cost utility rankings of the seven medical procedures. When a joint replacement duration of 5 years is assumed, this proportion rises to 98 out of the 160 examples. The respective figures for the osteoarthritis group are 44, 50 and 70 (out of 132 examples). For the post-traumatic arthritis group, the respective figures are 59, 72 and 100 (out of 178 examples).

The sensitivity of Gudex's Cost per QALY estimate for shoulder joint replacement surgery can be illustrated with an example from the rheumatoid arthritis group. Let us assume that preoperative health-related quality of life is graded as Rosser Category IVC-D and that postoperatively, the full exercise programme categories are converted into Rosser Categories as follows: A=IB, B=II-III B, C=IV-VC-D, D=IVB and E=VD. Let us also assume that the duration of a joint replacement is 10 years. Despite these very minor changes to Gudex's assumptions, the Cost per QALY estimate increases almost fivefold to £2,805 and Gudex's cost utility rankings of the seven medical procedures are altered as follows (with the pre-sensitivity analysis rankings shown in brackets):

**Table 4.8: Gudex's Cost Utility Rankings after Sensitivity Analysis of Shoulder Joint Replacement Data**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Treatment of cystic fibrosis with ceftazidime	£8,225 (3)
Shoulder joint replacement	£2,805 (6)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Kidney transplant	£1,413 (5)
Scoliosis surgery - neuromuscular illness	£194 (7)

Thus, Gudex's Cost per QALY estimate for shoulder joint replacement surgery is shown to be sensitive to her assumptions. This sensitivity is not confined to the assumption concerning the duration of the shoulder joint (since the cost of the operation occurs on a one-off basis, one would expect the cost effectiveness of the medical procedure to increase as the benefits accruing from the operation are enjoyed over a longer period). Rather, the Cost per QALY estimate is also very sensitive to Gudex's assumptions concerning preoperative health-related quality of life and the conversion of Cofield's full exercise programme categories into Rosser Categories.

Gudex also estimated the health-related quality of life of a group of patients who had elbow joint replacements, though this medical procedure does not feature in her final cost utility 'league table'. The source of patient outcome was a study by Soni and Cavendish (1984) who evaluated the success of 80 elbow joint replacements in 65 patients. Gudex converted the outcome data on function and pain into Rosser Categories as follows:



**Table 4.9: Gudex's Conversion of Soni and Cavendish Function Categories into Rosser Disability Categories**

Soni and Cavendish Function Categories	Number of Elbows- Before Operation	Number of Elbows- After Operation	Rosser Disability Categories
A: Excellent: Stable, good range of movement.	0	42	I-II
B: Good: Complications requiring revision but patient satisfied.	0	15	III
C: Fair: Discomfort but could carry out some daily activities.	80	9	IV
D: Poor: Poor range of motion, patient dissatisfied		14	V

**Table 4.10: Gudex's Conversion of Soni and Cavendish Pain Grading Categories into Rosser Distress Categories**

Soni and Cavendish Pain Grading Categories	Number of Elbows- Before Operation	Number of Elbows- After Operation	Rosser Distress Categories
a. Normal	3	65	A
b. Slight	7	10	B
c. Moderate	27	5	C
d. Severe	43	0	D

As a result of these conversions, Gudex estimated a preoperative health-related quality of life score of 0.85 and a postoperative health-related quality of life score of 0.98. Assuming a joint survival of 5 to 8 years, she calculated that the QALY's gained per patient were 0.5-0.9.

Appendix 26 tabulates a sensitivity analysis of Gudex's conversion of Soni and Cavendish's Function Categories into Rosser Disability Categories at the preoperative and postoperative stages. The Appendix presents 96 alternative sets of conversions of the categories into the Rosser Classification. As in the

shoulder joint replacement sensitivity analysis, the final Cost per QALY estimate is shown to be sensitive to both the conversion into the Rosser Classification and the assumed duration of the joint. Assuming that an elbow joint replacement costs £533 (1986 prices), the extremes in the possible Cost per QALY estimates vary thirtyfold.

#### (e) Ceftazidime Treatment of Cystic Fibrosis

Gudex's estimate of the health-related quality of life of cystic fibrosis patients is based on the psychological adjustment of 27 young adults studied by Boyle et al. (1976). All the patients in this study had been given a rating score according to one of two disease-specific scales, the National Institute of Health (NIH) Clinical Score of Taussig et al. (1973) or the Shwachman and Kulczycki scale (1958). Gudex argues that these two scores are good indicators of general activity and converts them into Rosser Disability Categories as follows:

**Table 4.11: Gudex's Conversion of Cystic Fibrosis Clinical Scores into Rosser Disability Categories**

Taussig / Shwachman and Kulczycki Score	Number of Patients	Rosser Disability Category
86-100	5	I
71-85	8	II
56-70	9	III-IV
41-55	4	V-VI
0-40	1	VII

Gudex categorizes both clinical scores into the same Rosser Disability Categories, even though the scores are composed of different elements. Indeed, Shwachman and Kulczycki consider patient status to be excellent when their score is over 85, good when their score is between 71 and 85, mild when between 56 and 70, moderate between 41 and 55, and severe when 40 or

below. Taussig et al., on the other hand, consider patients with NIH scores of 91 to 100, 81 to 90, 71 to 80, 61 to 70, and less than 60 as having excellent, very good, good, fair, and poor prognoses, respectively. It seems therefore that Gudex may be mistaken in categorizing both clinical scores into the same Rosser Disability Categories (a more detailed discussion of Gudex's assumptions concerning the health-related quality of life of cystic fibrosis patients follows in the Chapter 5). Boyle et al. also graded the 27 patients in terms of daily coping skills which Gudex converts into Rosser Distress Categories as follows:

**Table 4.12 : Gudex's Conversion of Boyle et al's Daily Coping Skills Categories into Rosser Distress Categories**

Boyle et al's Daily Coping Skills	Number of Patients	Rosser Distress Categories
Good	13	B
Fair	6	C
Poor	8	D

After the two sets of conversions, Gudex multiplied the proportion of the 27 patients who fell into each Rosser Disability/Distress Category by the valuation for that category, and obtained a health-related quality of life score of 0.91 for cystic fibrosis patients on 'established treatment'. However, Boyle et al. do not inform us of the treatment of the 27 subjects, and Gudex does not define the term 'established treatment'.

Gudex then makes the assumption that ceftazidime treatment does not reduce patient disability, but leads to half the patients in each distress category moving up to the next highest distress category. As a result, the average health-related quality of life score of the Boyle et al. group of subjects increases to 0.94. Combined with the additional assumptions of an annual cost per patient of £250 (1986 prices) and a treatment duration of 22 years, the final Cost per QALY estimate is £8,225.

Appendix 27 tabulates a sensitivity analysis of Gudex's conversion of the two clinical scores into Rosser Disability Categories. It also tabulates a sensitivity analysis of Gudex's conversion of the Daily Coping Skills Categories into Rosser Distress Categories for patients on 'established' and ceftazidime treatment. Fourteen alternative sets of conversions into the Rosser Classification are presented. A more detailed analysis of Gudex's assumptions will be discussed in Chapter 5, but what is clear from this sensitivity analysis of her conversions into the Rosser Classification is that her final Cost per QALY estimate is very sensitive to her assumptions. For example, let us assume that the two clinical scores are converted into Rosser Disability Categories as follows: 81-100=I, 70-80=II, 50-69=III-IV, 40-49=V-VI and 0-39=VII. Let us also assume that for patients on 'established' treatment, the Daily Coping Skills Categories are converted into Rosser Distress Categories as follows: Good=B, Fair=C and Poor=D, and that ceftazidime treatment results in all patients in each Distress Category moving up to the next highest category. Leaving the assumption of the treatment duration unchanged, the Cost per QALY estimate increases to £12,658. This alters Gudex's cost utility rankings of the seven medical procedures as follows (with the pre-sensitivity analysis rankings shown in brackets):

**Table 4.13: Gudex's Cost Utility Rankings after Sensitivity Analysis of Ceftazidime Treatment of Cystic Fibrosis Data (1)**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Treatment of cystic fibrosis with ceftazidime	£12,658 (3)
Haemodialysis	£9,075 (2)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

Alternatively, let us assume that the two clinical scores are converted into Rosser Disability Categories as follows: 86-100=I, 75-85=II, 65-74=III-IV, 50-64=V-VI and 0-49=VII. Let us also assume that for patients on established treatment, the Daily Coping Skills Categories Good, Fair and Poor are converted into Rosser Distress Categories B, C and D respectively, and that ceftazidime treatment results in all patients in each Distress Category moving up to the next highest category. Assuming a treatment duration of 23 years, the Cost per QALY estimate decreases to £2,278. This alters Gudex's cost utility rankings of the seven medical procedures as follows (with the pre-sensitivity analysis rankings shown in brackets):

**Table 4.14: Gudex's Cost Utility Rankings after Sensitivity Analysis of Ceftazidime Treatment of Cystic Fibrosis Data (2)**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Treatment of cystic fibrosis with ceftazidime	£2,278 (3)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

Thus, Gudex's Cost per QALY estimate for ceftazidime treatment of cystic fibrosis is shown to be sensitive not only to her conversions of the outcome data into the Rosser Classification, but also her assumption concerning the duration of ceftazidime treatment. The sensitivity analysis of her assumptions results in Cost per QALY estimates which shift the procedure between second and fourth place in the 'league table' of the seven medical programmes.

## (f) Treatment for Idiopathic Adolescent Scoliosis

Gudex estimates the health-related quality of life of patients treated for idiopathic adolescent scoliosis by converting the outcome data presented by Van Grouw et al. (1976) into the Rosser Classification. Van Grouw et al. (1976) had evaluated 51 patients, who underwent surgery for idiopathic adolescent scoliosis between 1960 and 1966, over an average follow-up period of 10.2 years. They recorded the experience of activity and pain of these patients which Gudex converts into Rosser Disability and Distress categories as follows:

**Table 4.15 : Gudex's Conversion of Van Grouw et al. Activity Categories into Rosser Disability Categories**

Van Grouw et al. Activity Categories	Number of Patients	Rosser Disability Categories
I: Indoor activities of a sedentary nature which were least strenuous such as reading, art or sewing.	3	IV
II	8	IV
III	28	III
IV: Most strenuous activities which demanded endurance and placed the most significant stresses on the back such as skiing, mountain climbing and all contact sports.	12	I-II

**Table 4.16: Gudex's Conversion of Van Grouw et al. Pain Categories into Rosser Distress Categories**

Van Grouw et al. Pain Categories	Number of Patients	Rosser Distress Categories
Grade 1: No back symptoms	10	A
Grade 2: Rare annoying backache	12	B
Grade 3: Occasional annoying backache	15	C
Grade 4: Frequent but not restrictive annoying backache	7	C
Grade 5: Partially restrictive frequent to daily backache	6	D
Grade 6: Incapacitating daily back pain	1	D

By multiplying the proportion of the 51 patients who fell into each Rosser Disability/Distress Category by the valuation for that category, Gudex obtains an average health-related quality of life score of 0.96.

Gudex also evaluated the outcome data of one other study, which is not named or described, and arrives at an average health-related quality of life score of 0.97 for treated idiopathic adolescent scoliosis. She does not mention how this estimate was calculated, but it is probable that it is the average of the health-related quality of life estimates derived from the two studies. The QALY's gained from treatment were calculated by assuming untreated life expectancies of 40, 50, 60 and 70 years and assuming that without treatment, the average health-related quality of life score would fall to 0.95 at the age of 46 and to 0.91 at the age of 60.

In her final cost utility calculations, Gudex assumes a treated life expectancy of 77 years, and an untreated life expectancy of 60 years. With the additional assumption of a total, one-off, cost of treatment of £3,143 (1986 prices), a final Cost per QALY estimate of £2,619 is obtained.

Appendix 28 tabulates a sensitivity analysis of Gudex's conversion of Van Grouw et al's Activity and Pain Categories into Rosser Disability/Distress Categories and her assumption concerning untreated life expectancy. The Appendix tabulates 19 alternative conversions into the Rosser Classification. What emerges from the sensitivity analysis is that alternative conversions of the activity and pain categories into Rosser Disability/Distress Categories have little effect on Gudex's final Cost per QALY estimate. For example, assuming an untreated life expectancy of 60 years, the Cost per QALY estimates in all the examples of the sensitivity analysis only vary between £2,686 and £2,883. This has no effect on Gudex's cost utility rankings of the seven medical procedures. However, varying the life expectancy of untreated patients has a noticeable effect on the Gudex's final Cost per QALY estimate. When an untreated life expectancy of 50 years is assumed, the Cost per QALY estimates

in all the examples of the sensitivity analysis vary between £1,267 and £1,367. This pushes the treatment for idiopathic adolescent scoliosis down the league table as shown below (the pre-sensitivity analysis rankings are shown in brackets). In other words, the medical procedure appears more cost effective.

**Table 4.17: Gudex's Cost Utility Rankings after Sensitivity Analysis of Scoliosis Surgery for Idiopathic Adolescents Data (1)**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Treatment of cystic fibrosis with ceftazidime	£8,225 (3)
Kidney transplant	£1,413 (5)
Scoliosis surgery - idiopathic adolescent	£1,267-£1,367 (4)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

When an untreated life expectancy of 70 years is assumed, the Cost per QALY estimates in all the examples of the sensitivity analysis vary between £8,495 and £9,244 (Appendix 28). This pushes the treatment for idiopathic adolescent scoliosis up the league table as shown below (the pre-sensitivity analysis rankings are shown in brackets). In other words, the medical procedure appears less cost effective.



**Table 4.18: Gudex's Cost Utility Rankings after Sensitivity Analysis of Scoliosis Surgery for Idiopathic Adolescents Data (2)**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Scoliosis surgery - idiopathic adolescent	£8,495-£9,244 (4)
Treatment of cystic fibrosis with ceftazidime	£8,225 (3)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

Therefore, the cost effectiveness of the treatment of idiopathic adolescent scoliosis is very sensitive to the assumption concerning the life expectancy of untreated patients. The longer that life expectancy, the shorter the period over which the benefits of treatment are enjoyed and hence the less cost effective the medical procedure appears.

**(g) Scoliosis Secondary to Neuromuscular Illness**

When estimating the health-related quality of life of patients operated on for scoliosis secondary to neuromuscular illness, Gudex formulates her own assumptions, rather than convert outcome data available in the medical literature into the Rosser Classification. For patients who forgo the operation, a life expectancy of 30 years is assumed, whilst it is assumed that operated patients were surgically treated at 14 years of age and have a life expectancy of 40 years. We are informed that the purpose of the operation is to prevent patients, who are already chairbound, from becoming bedridden after 14 years of age. Hence, Gudex conveys the alternatives as either 26 years in Rosser

Category VID (with operation) or 16 years in Rosser Category VIID (without operation). As a result of these assumptions, Gudex calculates a gain in QALY's from the operation of 16.2. With a total one-off cost of £3,143 (1986 prices), the final Cost per QALY gained for scoliosis surgery secondary to neuromuscular illness is £194, making the procedure the most cost effective of the seven analysed by Gudex.

Appendix 29 summarizes the effects of alternative assumptions about the health states of surgically treated and surgically untreated patients and the life expectancy of surgically treated patients on the final Cost per QALY estimate. In total, 81 alternative sets of assumptions are presented. Once again, Gudex's final Cost per QALY estimate is found to be sensitive to minor alterations in her assumptions. For example, if we slightly alter one of her assumptions and assume that the health state of patients who forgo the operation falls into Rosser Category VI-VIIC-D, the Cost per QALY estimate for surgery increases to £1,442. This pushes surgery for scoliosis secondary to neuromuscular illness up the 'league table' as shown below (the pre-sensitivity analysis rankings are shown in brackets). In other words, the procedure becomes less cost effective.

**Table 4.19: Gudex's Cost Utility Rankings after Sensitivity Analysis of Scoliosis Surgery for Neuromuscular Illness Data**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Treatment of cystic fibrosis with ceftazidime	£8,225 (3)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Scoliosis surgery - neuromuscular illness	£1,442 (7)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)

Therefore, the cost effectiveness of surgery for scoliosis secondary to neuromuscular illness is sensitive to Gudex's assumptions about the health states of surgically treated and surgically untreated patients. In addition, the life expectancy of surgically treated patients affects the final Cost per QALY estimate. The shorter that life expectancy, the shorter the period over which the benefits of treatment are enjoyed and hence the less cost effective the medical procedure appears.

#### **4.42 Sensitivity Analysis of Discount Rate**

The discounting process reduces the costs and benefits of health care programmes to their present values and allows us to compare the relative effectiveness of each programme with alternatives. Typically, this involves deflating future costs and benefits by an increasing proportion.

Discounting is necessary to reflect the preferences of individuals and of society as a whole for current consumption, that is we tend to place greater value on current resources as opposed to future resources. There are several possible explanations for this. First, the notion that most of us are naturally short-sighted and prefer the option of benefiting from resources in the present. Second, people's perception of inflation is likely to erode the value of resources over time. Third, even in an inflation-free economy, we can benefit from the investment of those resources and the subsequent interest which accrues. Fourth, we must allow for the uncertainty surrounding our future existence and our future investments. Finally, since consumption is likely to increase in the future, the principle of diminishing marginal utility implies that greater weight should be placed on current consumption.

Sorkin (1975), Irvin (1978), Warner and Luce (1982) and Drummond et al. (1987) outline the procedures required to deal with inflation in the economy when discounting future costs and benefits to their current values. The

general consensus is that future cost and benefit streams should be expressed at current levels before discounting. In addition, Sorkin (1975) illustrates how productivity changes in the economy affect the calculation of the net effective discount rate.

The discounting process has been widely criticised. The problems involved in the measurement of the costs and benefits of health care programmes and in deciding which costs and benefits should be discounted are well documented [Ward (1975), Sorkin (1975), Sassone and Schaffer (1978), Cullis and West (1979), Mooney et al. (1980)]. Cullis and West (1979) question the entire logic of placing greater weight on the current consumption of health care resources. Despite increasing affluence, they argue, the value of health is likely to increase in the future. (Unlike other commodities, the demand for health care is virtually infinite). The utilitarian hypothesis [Dasgupta and Pearce (1978)] emphasizes this generation's responsibility for the welfare of future generations. A related criticism is the seemingly callous discounting of future health benefits as explained by Drummond et al. (1986). However, powerful counter-arguments are presented by Weinstein and Stason (1977) and Warner and Luce (1982).

Much disagreement surrounds the choice of an appropriate discount rate for health care programmes (the social discount rate). Two alternatives prevail: the interest rate that commercial banks charge for business loans and the real rate of return on long-term government bonds [Sorkin (1975), Drummond et al. (1987)]. Sassone and Schaffer (1978) present arguments for setting the social discount rate both below and above the market interest rate. However, a public sector discount rate recommended by the UK Treasury provides assistance in this technical decision.

The discounting procedure has been applied in a multitude of academic papers in the health care field. A striking feature of these applications is the range of discount rates that have been employed, though the tendency since

1980 has been to use a central rate of 5-6% with many papers also using higher and lower rates to test the sensitivity of their findings (Table 4.20, page 131). The variation that does exist between the discount rates used in the literature does not seem to be accounted for by the inflation rate prevailing in the economy at the time of the study (Table 4.20, page 131).

To test whether the basic conclusions of the Gudex study are sensitive to slight variations in the discount rate, a sensitivity analysis was performed on the assumed 5 percent rate. The Cost per QALY estimates for each of the seven medical procedures have been recalculated using discount rates between 0 percent and 10 percent. This range of discount rates was chosen to cover the range previously used in the health care literature (Table 4.20, page 131). Though a 0 percent discount rate is unusual, and in some senses controversial, the recent favour it has found with the Department of Health [Parsonage and Neuburger (1991)] supports its inclusion in the sensitivity analysis. The discount rate was the sole variable in this sensitivity analysis. The health-related quality of life scores, the time horizon of each health programme and the annual cost of each health programme were identical to those estimated by Gudex.

The effects of alternative discount rates on the relative cost effectiveness of each of the medical procedures are displayed in Table 4.21 (page 134). Surgery for idiopathic adolescent scoliosis is particularly affected by the exercise. Its Cost per QALY increases from £191, assuming a discount rate of 0 percent, to £31,430 when a discount rate of 10 percent is applied. (In other words, if a 0 percent discount rate is used, surgery for idiopathic adolescent scoliosis is the second most cost effective of the seven medical procedures. If a 10 percent discount rate is used, this procedure becomes the least cost effective). Kidney transplant surgery, shoulder joint replacement surgery and scoliosis surgery for neuromuscular illness also appear less cost effective when the discount rate is increased, though to a lesser degree. The cost effectiveness of CAPD,

haemodialysis and ceftazidime treatment of cystic fibrosis remain unaffected by the exercise.

The effects of the application of alternative discount rates on the Costs per QALY for four procedures are illustrated in Figure 4.1 (page 135). These four procedures were selected to include the shortest and longest time spans for programmes with either recurring costs (CAPD and ceftazidime treatment of cystic fibrosis) or costs incurred only at the beginning of the programme (kidney transplant surgery and surgery for idiopathic adolescent scoliosis).

The effects of applying alternative discount rates can be explained as follows. Discounting converts the future costs and benefits of health care programmes to their present values by multiplying them by a weighting factor. This weighting factor diminishes the further in the future those costs and benefits arise. Let us define the time horizon of a health project as 'n' and the weighting factor as 'f'. As n tends to infinity then f tends to zero and as n tends to zero then f tends to 1. In other words, f varies inversely between 0 and 1 depending on the time horizon of the project. It follows from this that whatever the discount rate the project analyst decides to use, long-lived projects will be penalized because benefits accruing in the distant future will add little to the present value of the project. The low weighting factor will reduce distant benefits to relatively insignificant levels.

Increases in the discount rate also progressively depreciate the present value of future costs and benefits. Let us define the discount rate applied to reduce future costs and benefits as 'r'. It follows that whatever the time profile of the health project, as r tends to infinity then f tends to zero and as r tends to zero then f tends to one. By increasing the discount rate, the project analyst is in effect increasing the relative importance of current consumption. It is clear that both the time horizon of health projects and the discount rate affect the value of the weighting factor. The formula for this factor is

$$f=(1+r)^{-n}.$$

In our sensitivity analysis of Gudex's data, both variations in the time profiles of the health care programmes and the application of alternative discount rates have noticeable effects on the relative cost effectiveness of the seven medical procedures. In the case of surgery for idiopathic adolescent scoliosis, benefits occurring in the distant future, particularly 50 years or more in the future, add little to present QALY's per patient. As the discount rate is increased, future benefits are given progressively less weight and the QALY's gained per patient by the procedure fall. Since costs occur on a one-off basis and therefore need not be discounted, the Cost per QALY estimate for the procedure rises dramatically. Analogous falls occur in the cost effectiveness of the kidney transplant, shoulder joint replacement and surgery for neuromuscular illness scoliosis procedures, though to a lesser degree since the time spans of these programmes are shorter. In the CAPD, Haemodialysis and treatment of cystic fibrosis with ceftazidime procedures, costs recur annually throughout the period of the programmes and therefore are also discounted to present values. The resulting effect on the relative cost effectiveness of these programmes of discounting future costs as well as future benefits is that the reduced present values will tend to cancel each other out. In any case, the time spans of these programmes are shorter than that of the surgery for idiopathic adolescent scoliosis, implying that even if their costs did all occur on a one-off basis and therefore did not have to be discounted, their relative decrease in cost effectiveness would not be quite so evident.

A simulation of the data Gudex uses to arrive at her results is shown in Figure 4.2 (page 135), comparing Costs per QALY with variations in the discount rate. It confirms what we have been arguing. According to the simulated data, Costs per QALY increase as the discount rate rises, whatever the time span of the health care programme. All curves slope upwards from left to right. In other words, increases in the discount rate reduce the present

value of the benefits of the health care programme (QALY's). Since the simulated data assumes that costs occur on a one-off basis and therefore are not discounted, Costs per QALY rise.

If we study the graph in more detail, we can see that Costs per QALY fall with increases in survival periods resulting from any of the medical procedures, when discount rates below 4.5 percent are applied. However, between discount rates of 5 and 6 percent, Costs per QALY become insensitive to the length of the survival period. When discount rates greater than 6 percent are applied, Costs per QALY fall with increases in the survival period but only up to a certain point. For long-term survival periods, greater than 35 years, Costs per QALY increase noticeably.

In other words, the choice of discount rate can discriminate against health care programmes with benefits accruing in the more distant future. A low discount rate extols the virtues of long-lived projects. The project analyst is, in effect, making a value judgment by choosing a low social discount rate. He is stating that society is prepared to wait for the benefits of the project. Hence, when costs as well as benefits are taken into account, long-lived projects with benefits occurring 35, 40 and 50 years into the future appear to be more cost effective than short-lived projects at low social discount rates. However, as the discount rate increases, progressively less weight is given to future benefits (the weighting factor diminishes). The project evaluator, perhaps myopically, is stating society's preference for present over future consumption. High discount rates introduce a bias against long-lived projects. Hence, the cost effectiveness of health care programmes with benefits occurring in the distant future noticeably diminishes.

The above assertions have important implications and should be taken into account when projects allocating finite health care resources use discount rates to reduce future costs and benefits to their present values. It has been shown that the discount rate applied makes a considerable difference.



Therefore, when the discounting process is employed to evaluate the relative cost effectiveness of alternative health care programmes, special consideration must be given to selecting the appropriate rate. Whichever rate is chosen, a value judgment is in fact being made on our preference for current over future consumption.

#### 4.5 Conclusions

This chapter has illustrated the sensitivity of Gudex's final cost utility estimates to her assumptions concerning the accruing benefits from each of the seven medical procedures studied. Only two of the seven cost utility estimates, those for CAPD and Haemodialysis, were shown to be robust after sensitivity analyses of the three variables underlying their 'effectiveness' calculations (the health-related quality of life score, the survival period / treatment duration and the discount rate). Two other cost utility estimates, those for shoulder joint replacement surgery and surgery for scoliosis secondary to neuromuscular illness, were shown to be sensitive to all three variables. The cost utility estimates of renal transplantation, ceftazidime treatment of cystic fibrosis and scoliosis surgery for idiopathic adolescents, were shown to be sensitive to two of the three variables. Moreover, sensitivity analyses of all three variables produced results which altered Gudex's cost utility rankings of the seven medical procedures.

Some of the other assumptions underlying Gudex's results, for example that the subjects analysed in each study are representative of all patients undergoing those medical procedures and that the improved health-related quality of life scores attained by patient groups remain constant over the duration of their extended lives or the stated duration of improvement, are

also debatable. A discussion of Gudex's cost estimates will follow later on in the thesis (Chapter 6).

This chapter has raised some important doubts about Gudex's results. It seems that, in focussing on sources of information on patient outcomes that are comparable to the Rosser Classification, she may have inadvertently based some of her results on unrepresentative studies [the studies by Evans et al. (1985) and Boyle et al. (1976) for example]. Assumptions have been made which are not supported by the medical literature. Moreover, no sensitivity analysis of her results is presented. The results of this chapter emphasize the importance of the accurate measurement of health-related quality of life estimates in cost utility calculations.

**TABLE 4.20: EXAMPLES OF ALTERNATIVE DISCOUNT RATES USED IN PREVIOUS COST BENEFIT ANALYSES OF HEALTH CARE PROGRAMMES**

YEAR OF STUDY	DISCOUNT RATE (%)	INCREASE IN RETAIL PRICE INDEX IN YEAR OF STUDY (%)*	HEALTH CARE PROGRAMME	REFERENCE
1958	4	3	Hospitalization and treatment of mental illness	Fein (1958)
1965	4	5	Eradication of syphilis	Klarman (1965)
1966	10	4	Birth control	Enke (1966)
1971	10	9	Treatment of pulmonary tuberculosis	Pole (1971)
1973	4	9	PKU screening programme	Steiner and Smith (1973)
1980	10	18	New vascular grafts	Adar and Pliskin (1980)
1980	2,6,10	18	Cancer, motor vehicle injuries, coronary heart disease and stroke	Hartunian et al. (1980)
1980	3,7	18	Epilepsy clinics	Kriedel (1980)
1980	0-20	18	Treatment for end-stage renal failure	Roberts et al. (1980)
1980	4-15	18	Continuous immunization programme for measles	Ponnighaus (1980)
1980	5	18	Estrogen use in postmenopausal women	Weinstein (1980)
1980	6,10	18	X-linked recessive cardiac and humeroperoneal neuromuscular disease	Wright and Elsas (1980)
1981	5	12	Cholesterol levels in children	Berwick et al. (1981)

1981	5,7,10	12	Duodenal ulcer treatment	Culyer and Maynard (1981)
1981	2-10	12	Long term domiciliary oxygen therapy	Lowson et al. (1981)
1981	7,10,15	12	Treatment of chronic renal failure	Ludbrook (1981)
1981	5	12	Coronary Artery Bypass Graft Surgery	Pliskin et al. (1981)
1981	10	12	Alcoholism treatment programmes	Rundell et al. (1981)
1981	14	12	Prenatal detection of Down syndrome and neural tube defects in older mothers	Sadovnick and Baird (1981)
1982	5	9	Lead screening	Berwick and Komaroff (1982)
1982	4,7,10	9	Screening for open spina bifida	Henderson (1982)
1982	6,10,15	9	Second-opinion programmes	Ruchlin et al. (1982)
1982	5	9	Coronary Artery Bypass Surgery	Weinstein and Stason (1982)
1983	5	5	Neonatal intensive care of very low birth weight infants	Boyle et al. (1983)
1984	5	5	Experimental behaviour programme for patients with chronic obstructive pulmonary disease	Toevs et al. (1984)
1985	4,8	6	Thalassemia disease prevention programme	Ostrowsky et al. (1985)

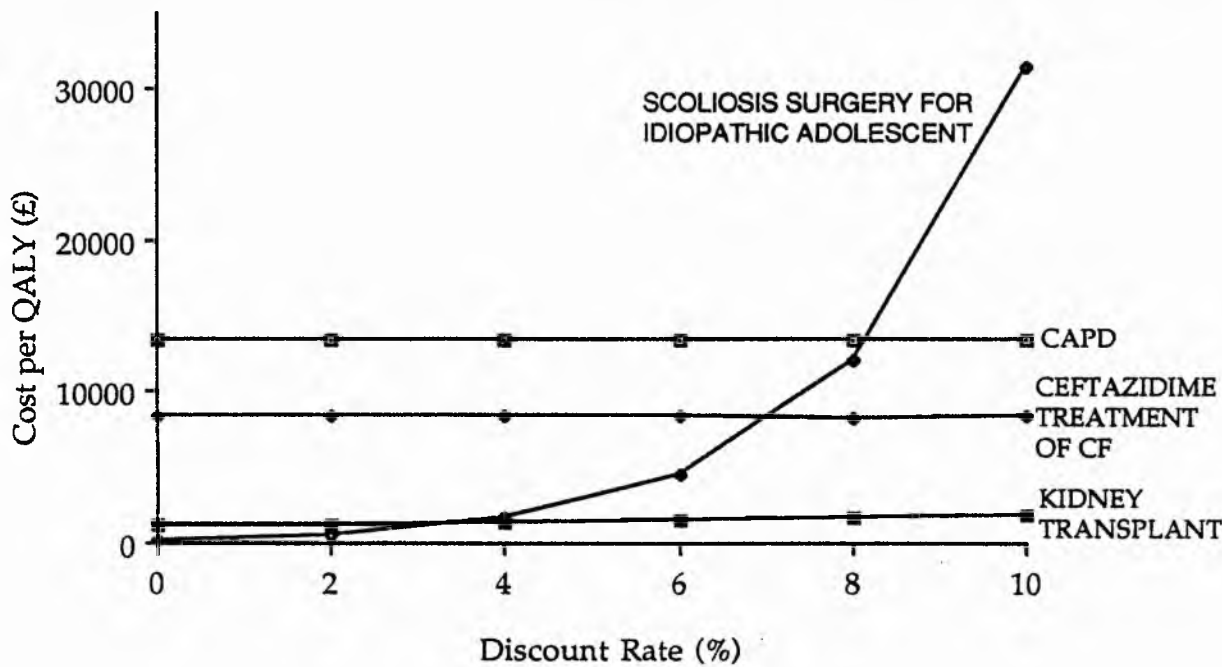
1986	5	3	Various health care programmes	Gudex (1986)
1986	0,10	3	North karelia hypertension programme	Nissinen et al. (1986)
1987	0-20	4	Health projects in Ghana	Barnum (1987)
1987	6	4	Multiple sclerosis	Inman (1987)
1987	5	4	Lithiotripsy	Labelle et al. (1987)
1987	2	4	Compensation of asbestos victims	Siskind (1987)
1988	5	5	Prenatal maternal serum alpha-feto protein screening	Taplin et al. (1988)
1989	5	8	External costs of sedentary life-style	Keeler et al. (1989)
1990	4,7,10	9	Prenatal diagnosis by amniocentesis	Goldstein and Philip (1990)

\* Source: 'Economic Trends' - Central Statistical Office

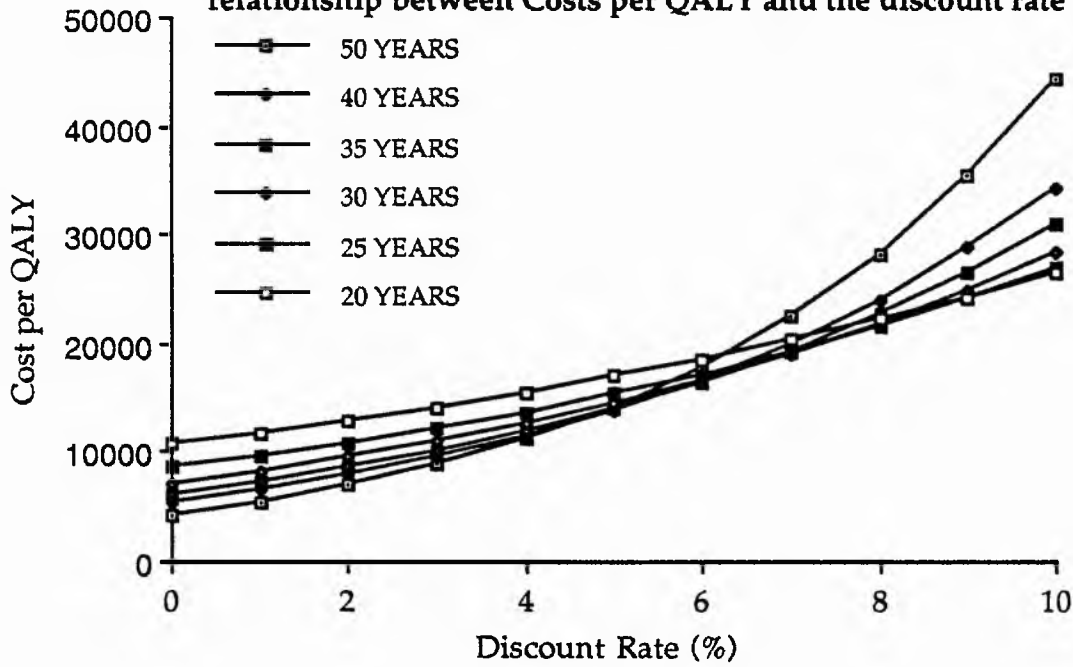
**TABLE 4.21 : EFFECTS OF ALTERNATIVE DISCOUNT RATES ON THE RELATIVE COST EFFECTIVENESS OF THE SEVEN MEDICAL PROCEDURES STUDIED BY GUDEx**

	Survival/ Life Expectancy (Years)	Cost per QALY  D.R. 0%	Cost per QALY  D.R. 2%	Cost per QALY  D.R. 4%	Cost per QALY  D.R. 6%	Cost per QALY  D.R. 8%	Cost per QALY  D.R. 10%
CAPD	4	£13,402	£13,385	£13,420	£13,388	£13,400	£13,416
Haemodialysis	8	£9,116	£9,111	£9,114	£9,112	£9,119	£9,125
Ceftazidime treatment of cystic fibrosis	22	£8,333	£8,330	£8,402	£8,361	£8,226	£8,435
Kidney transplant	10	£1,089	£1,213	£1,342	£1,478	£1,623	£1,772
Shoulder joint replacement	10	£485	£538	£599	£658	£720	£784
Scoliosis surgery - idiopathic adolescent	60	£191	£563	£1,620	£4,490	£12,088	£31,430
Scoliosis surgery - neuromuscular illness	30	£132	£156	£181	£209	£239	£270

**FIG. 4.1: Relative cost effectiveness of four of the medical procedures studied by Gudex as a result of the application of alternative discount rates**



**FIG. 4.2: A simulation of the data used by Gudex illustrating the relationship between Costs per QALY and the discount rate**



## CHAPTER 5

### BENEFITS OF ANTIBIOTIC TREATMENT OF CYSTIC FIBROSIS

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## 5.1 Introduction

In this chapter, the attempt by Gudex (1986) to use cost per quality adjusted life year (QALY) data to calculate the relative cost effectiveness of cystic fibrosis treatment with ceftazidime vis-à-vis six other medical procedures is analysed further. Of the seven medical procedures studied by Gudex, cystic fibrosis treatment with ceftazidime was selected for a more in depth analysis because the medical literature revealed a relatively large number of studies in this area which could be used as a basis for discussion and comparison. Initially, it was hoped that the information in the patient records of the cystic fibrosis patients at Ninewells Hospital, Dundee, could also be analysed. However, it was decided that the relatively small number of cystic fibrosis patients currently receiving treatment at the hospital (eight) would not provide us with any conclusive evidence, and hence the information available in the published literature forms the basis of discussion.

The chapter is structured as follows. First, Gudex's main arguments are outlined and a sensitivity analysis performed on her underlying assumptions. This is followed by a discussion of how reasonable these assumptions are by considering the placebo controlled trials to date and examining how effective antibiotics have in fact been in treating cystic fibrosis patients. A discussion of Gudex's cost assumptions for cystic fibrosis treatment will follow in a separate chapter (Chapter 6). Finally, in the light of the information revealed in the medical literature, some conclusions are offered.

## 5.2 Gudex's Assumptions about the Antibiotic Treatment of Cystic Fibrosis

### (a) Gudex's Overall Assumptions

Gudex calculated the Cost per QALY data for the seven different health care programmes using a method based on the Rosser-Kind Classification of Illness States. Of these seven programmes, the assumptions about the health-related quality of life of cystic fibrosis patients were based on a study by Boyle et al. (1976), which provided information about the psychological adjustment of 27 cystic fibrosis patients aged between 13 and 30 years. Of the 27 patients in the study, 22 were evaluated with the National Institute of Health (NIH) Clinical Score [Taussig et al. (1973)] and 5 were evaluated with the Shwachman-Kulczycki Score [Shwachman and Kulczycki (1958)]. Both scores are rated out of 100, but are made up of different parameters. The Shwachman-Kulczycki Score weights general activity, physical examination, nutrition and X-ray findings equally. The NIH Clinical Score, on the other hand, weights the pulmonary component very heavily (75 out of 100) with the remainder of the score made up of weight, activity and attitude. Gudex converted both scores into Rosser Disability Categories as follows:

**Table 5.1: Gudex's Conversion of Cystic Fibrosis Clinical Scores into Rosser Disability Categories**

Score	Rosser Disability Category
86-100	I
71-85	II
56-70	III-IV
41-55	V-VI
0-40	VII

The Boyle paper also provided information on the daily coping skills of the 27 patients which Gudex converted into Rosser Distress Categories as follows:

**Table 5.2: Gudex's Conversion of Boyle et al's Daily Coping Skills Categories into Rosser Distress Categories**

Boyle et al. Daily Coping Skills	Rosser Distress Category
Good	B
Fair	C
Poor	D

Gudex then multiplied the proportion of patients in each Rosser disability/distress category by the valuation for that category. In this way, she obtained a health-related quality of life score of 0.91 for patients on the established treatment for cystic fibrosis. Gudex then assumed that ceftazidime had no significant effect on patients' levels of disability. However, she also assumed that half the patients in each distress category moved up to the next highest category when treated with ceftazidime. This increased the health-related quality of life score to 0.94. When the health-related quality of life estimates were multiplied by life expectancy assumptions (discounted by 5%), ranges of QALY and Cost per QALY data were obtained.

The first point to make is that Gudex's conversion of both the Shwachman Score and the NIH score into equivalent Rosser Disability Categories implies that the disparate elements which make up the two scores have the same overall effect on the disability of cystic fibrosis patients. However, there is little evidence that this should be the case. Shwachman and Kulczycki consider patient status to be excellent when their score is over 85, good when their score is between 71 and 85, mild when between 56 and 70, moderate between 41 and 55, and severe when 40 or below. Taussig et al., on the other hand, consider patients with NIH scores of 91 to 100, 81 to 90, 71 to 80, 61 to 70, and less than 60 as having excellent, very good, good, fair, and poor prognoses, respectively. In Gudex's defence, the only study to date to use both scores to evaluate the health-related quality of life of cystic fibrosis patients. Levy et al. (1984) found that they yield broadly similar results. The authors studied the disposition of 12 cystic fibrosis patients to tobramycin in a

prospective controlled study. The mean Shwachman score of the patients was 52 (range 25-90), compared to a mean NIH score of 53 (range 42-88).

A second assumption which Gudex makes is that the 27 patients studied by Boyle et al. (1976) are representative of all cystic fibrosis patients on established treatment (which she does not define). In the Boyle study, the 27 patients had a mean overall clinical score of 69 (range 35-92). The 22 subjects rated by the NIH Score had a mean clinical score of 68 (range 35-92), and the 5 subjects rated by the Shwachman Score had a mean clinical score of 71 (range 54-86). Eleven other studies were found which used either the Shwachman Score or the NIH score to evaluate the health-related quality of life of cystic fibrosis patients. In 7 of these studies [Larsen et al. (1980), Gilbert et al. (1988), Strandvik (1988), Pan et al. (1989), Turck et al. (1989), Simmonds et al. (1990) and Sivan et al. (1990)], the mean clinical score was higher than that of the Boyle study. Of the four studies with lower mean clinical scores than the Boyle study [Hyatt et al. (1981), McLaughlin et al. (1983), Conway et al. (1985) and Levy et al. (1984)], the first three were studying cystic fibrosis patients who were in relapse at the time of admission to hospital, so they may not be representative samples of cystic fibrosis patients on 'established treatment'. It is possible therefore that Gudex has focussed on a sample of patients whose health-related quality of life, as measured by the two clinical scores, is slightly worse than the whole population of cystic fibrosis patients on 'established treatment'. As an exercise the eight cystic fibrosis subjects who had been screened by Simmonds et al. (1990) for allergic bronchopulmonary aspergillosis were used as a representative sample. The mean Shwachman score of this group was 82 (range 70-95). When the eight subjects were categorized according to the Rosser Classification, the average health-related quality of life score rose to 0.94-0.99 (depending on the assumptions about distress), compared to 0.91 estimated by Gudex.

Even if we accept that the two clinical scores have an equivalent overall effect on patient disability and that the 27 subjects in the study by Boyle et al. (1976) are representative of cystic fibrosis patients on established treatment, it may be the case that Gudex's overall results are sensitive to her categorisation of the two clinical scores and the coping skills parameter into Rosser Disability/Distress categories. The rigorousness of her assumptions were therefore tested in an extensive sensitivity analysis (Appendix 27) which considered 14 alternative and reasonable sets of conversions. The results of this sensitivity analysis are summarized below:

**Table 5.3: Examples of Sensitivity Analyses of Gudex's Quality of Life Score on Established Cystic Fibrosis Treatment**

Example of Sensitivity Analysis	Quality of Life Score on Established Treatment
1,2	0.96
9,10	0.95
3,4,5,6	0.94
11	0.87
12	0.86
7,8	0.81
13	0.79
14	0.78

As we can see in the table, Gudex's estimate of the health-related quality of life score on established treatment is sensitive to her categorisation of the two clinical scores and the coping skills parameters to Rosser Disability/Distress Categories.

Having demonstrated that Gudex's initial health-related quality of life score on established treatment is contingent on some debatable assumptions, the next section will test the sensitivity of her assumptions concerning the effects of ceftazidime treatment. The sensitivity of her cost utility result to the assumptions that ceftazidime treatment leads to half the patients in each Rosser Distress Category moving up to the next highest Distress Category, and

has no effect on patient disability and survival will be tested. This sensitivity analysis will not vary Gudex's pre-treatment conversion of Boyle's clinical rating score into Rosser Disability Categories or Gudex's pre-treatment conversion of Boyle's coping skills grades into Rosser Distress Categories.

(b) Patient Distress

As explained above, Gudex assumes that ceftazidime treatment leads to half the patients in each Rosser Distress Category moving up to the next highest Distress Category, resulting in an increase in the average health-related quality of life score of the 27 study patients from 0.91 to 0.94. The following table summarizes the implications of a sensitivity analysis of the possible reductions in patient distress on the cost effectiveness of ceftazidime treatment.

**Table 5.4: The Implications of Possible Reductions in Patient Distress on the Cost Effectiveness of Ceftazidime Treatment**

Change in Daily Coping Skills (Indicator of Patient Distress)	QALY's gained over Established Treatment	Total Costs (Discounted at 5%)	Cost per QALY
GUDEX	0.4	£3,290	£8,225
Good = A/B Fair = B/C Poor = C/D	0.26	£3,291	£12,658
Good = A Fair = B Poor = C	0.53	£3,291	£6,209
Good = A Fair = A/B Poor = B	0.66	£3,291	£4,986
Good = A Fair = A Poor = A	0.66	£3,291	£4,986

We can see from the table how sensitive Gudex's Cost per QALY estimate is to her assumption concerning the reduction in patient distress. In the second example above, assuming that patients in each of the coping skills grades only improve by half a Distress Category results in ceftazidime treatment appearing less cost effective. This has the effect of altering Gudex's cost utility rankings of the seven medical procedures studied as shown below, with the pre-sensitivity analysis rankings shown in brackets:

**Table 5.5: Effect of a Smaller Reduction in Patient Distress as a Result of Ceftazidime Treatment on Gudex's Cost per QALY Rankings**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Treatment of cystic fibrosis with ceftazidime	£12,658 (3)
Haemodialysis	£9,075 (2)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

Assuming greater reductions in patient distress than Gudex does results in noticeably more cost effective estimates, but without altering her cost utility rankings of the seven medical procedures.

#### (c) Patient Distress and Patient Disability

Gudex assumes that ceftazidime treatment has no effect on patient disability. As an exercise, the assumption that ceftazidime treatment of cystic fibrosis improves both patient disability (as measured by the two clinical scores) and patient distress was tested. The results of the exercise can be seen in the table below.



**Table 5.6: The Implications of Possible Reductions in Patient Distress and Patient Disability on the Cost Effectiveness of Ceftazidime Treatment**

Change in Clinical Score (Indicator of Patient Disability)	Change in Daily Coping Skills (Indicator of Patient Distress)	QALY's gained over Established Treatment	Total Costs (Discounted at 5%)	Cost per QALY
<b>GUDEX</b>		<b>0.4</b>	<b>£3,290</b>	<b>£8,225</b>
0	Good = A/B Fair = B/C Poor = C/D	0.26	£3,291	£12,658
0	Good = A Fair = B Poor = C	0.53	£3,291	£6,209
0	Good = A Fair = A/B Poor = B	0.66	£3,291	£4,986
0	Good = A Fair = A Poor = A	0.66	£3,291	£4,986
+2	Good = B Fair = C Poor = D	0.26	£3,291	£12,658
+2	Good = A/B Fair = B/C Poor = C/D	0.39	£3,291	£8,438
+2	Good = A Fair = B Poor = C	0.66	£3,291	£4,986
+2	Good = A Fair = A/B Poor = B	0.66	£3,291	£4,986
+2	Good = A Fair = A Poor = A	0.79	£3,291	£4,166
+5	Good = B Fair = C Poor = D	0.39	£3,291	£8,438
+5	Good = A/B Fair = B/C Poor = C/D	0.53	£3,291	£6,209
+5	Good = A Fair = B Poor = C	0.66	£3,291	£4,986
+5	Good = A Fair = A/B Poor = B	0.79	£3,291	£4,166
+5	Good = A Fair = A Poor = A	0.79	£3,291	£4,166
+10	Good = B Fair = C Poor = D	0.66	£3,291	£4,986

+10	Good = A/B Fair = B/C Poor = C/D	0.79	£3,291	£4,166
+10	Good = A Fair = B Poor = C	0.92	£3,291	£3,577
+10	Good = A Fair = A/B Poor = B	0.92	£3,291	£3,577
+10	Good = A Fair = A Poor = A	0.92	£3,291	£3,577
+15	Good = B Fair = C Poor = D	0.79	£3,291	£4,166
+15	Good = A/B Fair = B/C Poor = C/D	0.92	£3,291	£3,577
+15	Good = A Fair = B Poor = C	0.92	£3,291	£3,577
+15	Good = A Fair = A/B Poor = B	1.05	£3,291	£3,134
+15	Good = A Fair = A Poor = A	1.05	£3,291	£3,134
+20	Good = B Fair = C Poor = D	0.79	£3,291	£4,166
+20	Good = A/B Fair = B/C Poor = C/D	0.92	£3,291	£3,577
+20	Good = A Fair = B Poor = C	1.05	£3,291	£3,134
+20	Good = A Fair = A/B Poor = B	1.05	£3,291	£3,134
+20	Good = A Fair = A Poor = A	1.05	£3,291	£3,134

Table 5.6 illustrates the sensitivity of Gudex's cost utility estimate to any reduction in patient disability, as well as patient distress. It has been assumed that the two clinical scores (which Gudex uses as indicators of patient disability) increase by up to 20 points as a result of ceftazidime treatment. In addition, it has been assumed that patients in each of Boyle et al's Daily Coping Skills Categories (which Gudex uses as indicators of patient distress)

improve by varying degrees as a result of ceftazidime treatment, the best possible improvement being all patients in each of the Coping Skills Categories moving up to Rosser Distress Category A.

The only example in the table which alters Gudex's pre-sensitivity analysis cost utility rankings of the seven medical procedures is the one highlighted in the last section. However, the Cost per QALY estimates vary between £3,134 and £12,658, depending on the assumed reductions in disability and distress. In other words, the Cost per QALY estimates vary between 38% and 154% of Gudex's original Cost per QALY estimate. For example, assuming that antibiotic treatment leads to a 10 point increase in the clinical score results in ceftazidime treatment becoming twice as cost effective as originally estimated. Even a relatively small increase in the clinical score (an increase of 5 points), combined with a marked reduction in patient distress, results in ceftazidime treatment becoming twice as cost effective.

#### (d) Patient Distress, Patient Disability and Survival

In her final analysis, Gudex assumes that ceftazidime treatment lasts for 22 years, and has no effect on patient survival. As she states in her paper (page 34), this figure may be too high as it is based on the life expectancy of patients in specialised units [Batten (1983), Wilmott et al. (1983)]. It may be more sensible to assume an average life expectancy of cystic fibrosis patients of 17 years [Britton (1989)]. As an exercise, the assumption that ceftazidime treatment lasts for 22 years was varied. When it was assumed that ceftazidime treatment lasted for either 10 years or 17 years, and did not vary any of Gudex's other assumptions, it had very little effect on the cost effectiveness of the treatment, since costs and QALY's per case recur annually and hence the reduced absolute numbers in both tend to cancel each other out. However,

when it was assumed that ceftazidime treatment increases life expectancy, as well as reducing patient disability and distress, a noticeable effect on its cost effectiveness is seen (table 5.7).

As a sensitivity analysis (in brackets), it was also assumed that established treatment lasts for 17 years. (Even though this is a more realistic estimate, it is still likely to be on the high side.) The effects of a longer life expectancy of up to 20 years on the cost effectiveness of ceftazidime treatment are calculated.

**Table 5.7: The Implications of Possible Reductions in Patient Distress and Patient Disability and Possible Improvements in Life Expectancy on the Cost Effectiveness of Ceftazidime Treatment**

Change in Clinical Score (Indicator of Patient Disability)	Change in Daily Coping Skills (Indicator of Patient Distress)	Average Life Expectancy from Birth / Length of Treatment	Cost per QALY
GUDEX		22	£8,225
0	Good = A/B	22 (17)	£12,658 (£12,257)
	Fair = B/C	23 (18)	£5,196 (£4,790)
	Poor = C/D	24 (19)	£4,059 (£3,083)
		25 (20)	£3,118 (£2,343)
0	Good = A	22 (17)	£6,209 (£6,264)
	Fair = B	23 (18)	£4,014 (£3,438)
	Poor = C	24 (19)	£3,053 (£2,476)
		25 (20)	£2,499 (£1,972)
0	Good = A	22 (17)	£4,986 (£5,034)
	Fair = A/B	23 (18)	£3,476 (£3,044)
	Poor = B	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
0	Good = A	22 (17)	£4,986 (£5,034)
	Fair = A	23 (18)	£3,476 (£3,044)
	Poor = A	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
+2	Good = B	22 (17)	£12,658 (£12,257)
	Fair = C	23 (18)	£5,196 (£4,790)
	Poor = D	24 (19)	£4,059 (£3,083)
		25 (20)	£3,118 (£2,343)
+2	Good = A/B	22 (17)	£8,438 (£8,291)
	Fair = B/C	23 (18)	£4,817 (£4,003)
	Poor = C/D	24 (19)	£3,485 (£2,746)
		25 (20)	£2,774 (£2,134)
+2	Good = A	22 (17)	£4,986 (£5,034)
	Fair = B	23 (18)	£3,476 (£3,044)
	Poor = C	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
+2	Good = A	22 (17)	£4,986 (£5,034)

	Fair = A/B	23 (18)	£3,476 (£3,044)
	Poor = B	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
+2	Good = A	22 (17)	£4,166 (£4,146)
	Fair = A	23 (18)	£3,038 (£2,706)
	Poor = A	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+5	Good = B	22 (17)	£8,438 (£8,291)
	Fair = C	23 (18)	£4,817 (£4,003)
	Poor = D	24 (19)	£3,485 (£2,746)
		25 (20)	£2,774 (£2,134)
+5	Good = A/B	22 (17)	£6,209 (£6,264)
	Fair = B/C	23 (18)	£4,014 (£3,438)
	Poor = C/D	24 (19)	£3,053 (£2,476)
		25 (20)	£2,499 (£1,972)
+5	Good = A	22 (17)	£4,986 (£5,034)
	Fair = B	23 (18)	£3,476 (£3,044)
	Poor = C	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
+5	Good = A	22 (17)	£4,166 (£4,146)
	Fair = A/B	23 (18)	£3,038 (£2,706)
	Poor = B	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+5	Good = A	22 (17)	£4,166 (£4,146)
	Fair = A	23 (18)	£3,038 (£2,706)
	Poor = A	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+10	Good = B	22 (17)	£4,986 (£5,034)
	Fair = C	23 (18)	£3,476 (£3,044)
	Poor = D	24 (19)	£2,717 (£2,254)
		25 (20)	£2,273 (£1,833)
+10	Good = A/B	22 (17)	£4,166 (£4,146)
	Fair = B/C	23 (18)	£3,038 (£2,706)
	Poor = C/D	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+10	Good = A	22 (17)	£3,577 (£3,568)
	Fair = B	23 (18)	£2,719 (£2,435)
	Poor = C	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+10	Good = A	22 (17)	£3,577 (£3,568)
	Fair = A/B	23 (18)	£2,719 (£2,435)
	Poor = B	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+10	Good = A	22 (17)	£3,577 (£3,568)
	Fair = A	23 (18)	£2,719 (£2,435)
	Poor = A	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+15	Good = B	22 (17)	£4,166 (£4,146)
	Fair = C	23 (18)	£3,038 (£2,706)
	Poor = D	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+15	Good = A/B	22 (17)	£3,577 (£3,568)
	Fair = B/C	23 (18)	£2,719 (£2,435)

	Poor = C/D	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+15	Good = A	22 (17)	£3,577 (£3,568)
	Fair = B	23 (18)	£2,719 (£2,435)
	Poor = C	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+15	Good = A	22 (17)	£3,134 (£3,132)
	Fair = A/B	23 (18)	£2,443 (£2,231)
	Poor = B	24 (19)	£2,054 (£1,767)
		25 (20)	£1,788 (£1,498)
+15	Good = A	22 (17)	£3,134 (£3,132)
	Fair = A	23 (18)	£2,443 (£2,231)
	Poor = A	24 (19)	£2,054 (£1,767)
		25 (20)	£1,788 (£1,498)
+20	Good = B	22 (17)	£4,166 (£4,146)
	Fair = C	23 (18)	£3,038 (£2,706)
	Poor = D	24 (19)	£2,447 (£2,069)
		25 (20)	£2,085 (£1,703)
+20	Good = A/B	22 (17)	£3,577 (£3,568)
	Fair = B/C	23 (18)	£2,719 (£2,435)
	Poor = C/D	24 (19)	£2,240 (£1,912)
		25 (20)	£1,925 (£1,598)
+20	Good = A	22 (17)	£3,134 (£3,132)
	Fair = B	23 (18)	£2,443 (£2,231)
	Poor = C	24 (19)	£2,054 (£1,767)
		25 (20)	£1,788 (£1,498)
+20	Good = A	22 (17)	£3,134 (£3,132)
	Fair = A/B	23 (18)	£2,443 (£2,231)
	Poor = B	24 (19)	£2,054 (£1,767)
		25 (20)	£1,788 (£1,498)
+20	Good = A	22 (17)	£3,134 (£3,132)
	Fair = A	23 (18)	£2,443 (£2,231)
	Poor = A	24 (19)	£2,054 (£1,767)
		25 (20)	£1,788 (£1,498)

We can see from table 5.7 the sensitivity of Gudex's cost utility estimate to any increase in life expectancy. In the first example in table 5.7, the Cost per QALY estimate is reduced by three-quarters as a result of a three year increase in life expectancy. The Cost per QALY estimates vary between £1,498 and £12,658, depending on the assumed reductions in disability and distress and the assumed increases in life expectancy. In other words, the Cost per QALY estimates vary between 18% and 154% of Gudex's original estimate. As an example, let us assume that established treatment lasts for 17 years and that ceftazidime treatment extends life expectancy to 18 years, leads to a 10 point

increase in the clinical score and leads to each patient moving up to the next highest distress category. The Cost per QALY of cystic fibrosis treatment with ceftazidime falls to £2,435. This has the effect of altering Gudex's cost utility rankings as shown below, with the pre-sensitivity analysis rankings given in brackets:

**Table 5.8: Effect of a Greater Reduction in Patient Distress and Improvements in Patient Disability and Life Expectancy on Gudex's Cost per QALY Rankings**

Procedure	Cost per QALY
CAPD	£13,434 (1)
Haemodialysis	£9,075 (2)
Scoliosis surgery - idiopathic adolescent	£2,619 (4)
Treatment of cystic fibrosis with ceftazidime	£2,435 (3)
Kidney transplant	£1,413 (5)
Shoulder joint replacement	£592 (6)
Scoliosis surgery - neuromuscular illness	£194 (7)

### 5.3 Gudex's Assumptions Concerning Established Treatment

The last section demonstrated the sensitivity of Gudex's cost utility estimate of ceftazidime treatment to a range of assumptions concerning the efficacy of ceftazidime treatment relative to that of established treatment. In this section Gudex's lack of definition of *established treatment* and how its various possible definitions may lead to different outcomes in terms of costs and efficacy will be discussed.

Gudex calculated the health-related quality of life score of cystic fibrosis patients on established treatment by converting the information about the psychological adjustment of 27 cystic fibrosis subjects [Boyle et al. (1976)] into the Rosser-Kind Classification of Illness States. However, we are not told in

the Boyle paper what treatment the 27 subjects were receiving. It is not clear whether Gudex meant physiotherapy in combination with other forms of treatment when she used the term established treatment, or whether she meant the use of established antibiotics. If it is the former, then the analysis in the next section of the placebo-controlled antibiotic trials to date will clarify the efficacy of antibiotics relative to established treatment. If it is the latter, the same analysis will help us in estimating the efficacy of various antibiotics. Alternatively, the term established treatment may refer to an established method of treating cystic fibrosis patients with antibiotics. Cystic fibrosis patients can be treated using intravenous antibiotics, inhaled antibiotics or oral antibiotics. They can be treated at home or in hospital. They can be treated as each acute exacerbation occurs or their treatment can be planned prospectively. It is in this context that the discussion shall now focus on the various methods of treatment used in the main antibiotic trials to date and how they have affected the costs and efficacy of treatment.

An important issue which arises when we discuss the various methods of treating cystic fibrosis patients with antibiotics is the most effective method of delivering the drug. Most of the major antibiotic trials to date have delivered the drug intravenously.

Parry et al. (1977) tested the hypothesis that combination therapy with anti-Pseudomonas drugs is superior to single-drug therapy by randomizing patients with acute pulmonary exacerbations to treatment with intravenous ticarcillin alone, intravenous gentamicin alone, or the combination. Clinical and bacteriologic responses were similar in the three groups of patients. Beaudry et al. (1980) randomly assigned 22 children with cystic fibrosis and signs of acute lower respiratory infection to receive either cloxacillin or carbenicillin plus gentamicin administered intravenously for 10 days. Clinical improvement, chest radiograph changes, evidence of airway obstruction, and bacteriologic flora of sputum were no different regardless of the regimen



used. In the study by Martin et al. (1980), 18 children with cystic fibrosis were treated with intravenous courses either of gentamicin plus carbenicillin or tobramycin plus carbenicillin, with 2 children each receiving 2 courses. There was clinical and X-ray improvement in both groups of children, but there was no difference between the therapeutic benefit of either regimen. Intravenous piperacillin as a single drug was evaluated in an open, noncomparative trial and found to produce satisfactory results. In a comparative trial of piperacillin versus piperacillin and tobramycin, administered intravenously, there was no difference in clinical or bacteriologic results [Prince and Neu (1980)]. Of 24 exacerbations, Hyatt et al. (1981) treated 15 with oxacillin plus sisomicin and carbenicillin, and compared the results with 9 treated with oxacillin alone. Again, all the antibiotics were administered intravenously. The difference between the failure rate in the treatment group (3/15) and the control group (7/9) was found to be statistically significant ( $p$  less than 0.015). David et al. (1983) evaluated the effect of intravenous ceftazidime on 28 cystic fibrosis patients with severe infections. In 20 cases ceftazidime was the sole antibiotic, but in the first 8 of the 20 cases it was accompanied by oral flucloxacillin. There was an excellent clinical response in 27 courses, judged to be as good as the authors' former high dosage carbenicillin and tobramycin combination though with much greater patient acceptability. McLaughlin et al. (1983) compared 3 intravenous regimens: ticarcillin and tobramycin, azlocillin and tobramycin, and azlocillin and placebo. Clinical and bacteriologic responses were similar in the three groups. Permin et al. (1983) undertook two open randomized cross-over studies comparing ceftazidime to tobramycin and ceftazidime and ceftazidime to tobramycin and carbenicillin in 13 and 15 cystic fibrosis patients respectively, with chronic bronchopulmonary *Pseudomonas aeruginosa* infection. Patients receiving intravenous ceftazidime showed a tendency for greater long-term benefit in lung function as measured at 1 and 2 months after treatment than patients receiving the other intravenous

antibiotics. Conway et al. (1985) studied 17 cystic fibrosis patients who were in relapse at the time of admission in hospital. Patients were randomly allocated to an intravenous antibiotic regime of either netilmicin and ticarcillin or tobramycin and ticarcillin. Regular bronchodilator therapy using a nebuliser was administered to all patients with evidence of excessive bronchial liability. In addition, all patients received physiotherapy four times daily during their period of hospital treatment. A significant subjective and objective improvement occurred in all patients. *Pseudomonas* was cleared temporarily from the sputum in 11 out of the 30 courses of treatment. There was no significant difference between the netilmicin and tobramycin groups, nor evidence of sustained renal or ototoxicity. In all cases re-appearance of *Pseudomonas* occurred by the follow up visits four weeks later. In an evaluation of 30 patients treated intravenously with either ceftazidime or ticarcillin and tobramycin, Gold et al. (1985) found no significant differences between the 2 groups in terms of clinical responses, pulse rate, respiratory rate, white blood count (WBC) or erythrocyte sedimentation rate (ESR), forced expiratory volume in 1 second (FEV<sub>1</sub>) or midexpiratory flow rate (FEF<sub>25-75%</sub>), increase in weight. However, ceftazidime was significantly more effective in reducing sputum colony counts of *Pseudomonas aeruginosa*. The effect was more pronounced on nonmucoid than on mucoid strains. Unfortunately, the reduction in sputum colony counts achieved by treatment with ceftazidime was only transient. Within 1 to 2 months after discharge from the hospital, the colony counts had returned to pretreatment concentrations. Krilov et al. (1985) administered intravenous imipenem/cilastatin to 19 patients with pulmonary exacerbations of cystic fibrosis due to *Pseudomonas aeruginosa* for 6 to 10 days. They found that mean Shwachman scores, clinical efficacy scores, forced vital capacity (FVC) and FEV<sub>1</sub> all rose as a result of treatment. Strandvik (1988) evaluated the home treatment of 31 cystic fibrosis patients with an aminoglycoside and a cephalosporin or a ureidopenicillin for 1 year.

The mean duration of each intravenous course of therapy was 15.4 days and there was an average of 3 courses per patient. The author noted that all patients improved clinically. Van der Laag (1988) studied the administration of several combinations of intravenous antibiotics to 54 patients and found that antibiotic treatment led to good clinical results in 77% of all courses. In a recent trial by Steen et al. (1989), 12 cystic fibrosis patients who had developed an acute respiratory exacerbation and who had *Pseudomonas* species isolated from their sputum, were given intravenous ciprofloxacin twice daily. 11 of the 12 patients showed clinical improvement at the end of the treatment period.

In the studies by Penketh et al. (1982) and Wall et al. (1983), the antibiotics were inhaled by the patients, resulting in reduced hospital admissions. Penketh et al. (1982) found that the administration of inhaled gentamicin and carbenicillin in 41 patients over an average period of 21 months substantially reduced the frequency of hospital admissions from an average of 1.8 to 1.03 admissions per patient year. In the study by Wall et al. (1983), 11 cystic fibrosis patients chronically infected with *Pseudomonas aeruginosa* were treated with inhaled tobramycin and ticarcillin, twice daily. As a result, the frequency of hospital admissions was substantially reduced from 31 in the 89 patient-months before the initiation of therapy to only 5 in the same period afterwards. Hodson et al. (1981) found the use of aerosol antibiotics to be not only time consuming, taking most patients 20 minutes every morning and evening, but also an expensive form of treatment. Jensen et al. (1989) argue that the administration of antipseudomonal drugs by inhalation has proven clinically effective and has the advantage of being convenient for prolonged use. They argue that the main difficulties of this kind of therapy include technical problems of delivery of properly sized aerosol particles for deposition mainly in the lower airways, and uneven distribution of the drug within the lungs due to the unequal air exchange. Furthermore, there is a

potential risk of development of allergy or induction of bacterial resistance following inhalation of antibiotics. This could diminish the possibility of subsequent parenteral efficacy of the drug. Selection of multiple resistant organisms such as *Pseudomonas cepacia* is another potential risk. These advantages and disadvantages of the use of aerosols are also echoed by Mouton and Kerrebijn (1990) who add that most antibiotics taste rather badly, that it is unknown what quantity of the dose given is deposited in the lungs, and whether it reaches the infectious foci, and that hypersensitivity might be induced.

Another issue which arises when we discuss the methods of antibiotic treatment of cystic fibrosis patients is the best location for that treatment. Traditionally, patients requiring intravenous antibiotic treatment have had to remain in hospital. However, home therapy is becoming increasingly commonplace. Kuzemko (1988) argues that home therapy allows administration early in the course of a relapse, thus avoiding hospital admission. The risk of cross-infection from hospital patients harbouring drug-resistant *Pseudomonas aeruginosa* strains or other pathogens is eliminated. He lists the social benefits of home care therapy as little disruption to family life, school, and work hours, the fostering of independence from hospital and the continuity of total care in a home environment. Possible disadvantages to home care therapy are the additional burdens on the family, it may lead to anxiety, if unsuccessful, or to abuse, ie, unnecessary treatments, and it may lead to a deterioration in medical standards. Home treatment requires intensive cooperation among hospital pharmacists providing the intravenous antibiotic mixtures, nurses experienced in intravenous antibiotic administration, and physicians responsible for the medical care of the patient involved in such a home care treatment programme. Gilbert et al. (1988) argue that the advantages of hospital treatment are more effective physiotherapy and the reassurance of

having medical help at hand. The disadvantages of hospital treatment are considered to be the disruption and stress it causes even when mothers are resident and the financial strains on the patient's family. Patients with cystic fibrosis requiring intravenous treatment are often not acutely ill but place a great strain on the accommodation, manpower and financial resources of the hospital. The authors discuss the effect 40 courses of home intravenous antibiotic treatment had on 13 cystic fibrosis patients. They note highly significant improvements in weight, respiratory function, and white cell count during home treatment. There was no significant difference in weight and forced expiratory volume in one second between the end of home treatment and the end of hospital treatment while forced vital capacity was better after home treatment. All patients preferred home treatment. Most families found financial advantages of up to £110 per week because of reduced travelling expenses to hospital and because earnings were not lost. All families felt some degree of stress during home treatment but only 2 considered this greater than the stress of a hospital admission. On the basis of the cost of inpatient accommodation alone (assumed to be £81.37 per day), Gilbert et al. estimated the savings from the home intravenous service at £29,098 a year. In the study by Strandvik (1988), discussed above, all 31 patients treated with home intravenous antibiotic therapy improved clinically, the improvement being similar to that previously reported for in-hospital treatment. However, physiotherapy was less well performed at home. Nearly all patients could attend school or work during the entire treatment period. From an economic perspective, home treatment saved the hospital a mean of 3.5 beds per day for 1 year as well as the cost of the antibiotics themselves. Kuzemko and Williams (1986) estimated that the approximate hospital and home care costs (excluding antibiotics) in the UK for 30 patients amounted to £36,000 and £1,680 respectively. Forty-one home and 41 hospital treatments with tobramycin and a semisynthetic penicillin or tobramycin and a

cephalosporin were matched by Donati et al. (1987) according to sex, age, pulmonary function tests, and arterial blood gas values to compare the efficacy and benefits of the two types of treatment. Both home and hospital treatments resulted in statistically significant improvement in pulmonary function. A comparison of these values did not show any statistically significant difference between the groups at admission or discharge. Furthermore, the mean number of treatment days for both groups, individually determined by the primary physician, was equivalent. The interval between pulmonary exacerbations for the two groups was not significantly different. In addition, 85% of patients receiving treatment at home were able to maintain at least some of their school or work activities. The charges billed to the 2 groups were significantly different, with a mean charge of approximately \$10,000 (\$600/day) for home care patients and more than \$18,000 (\$1,000/day) for hospitalized patients, resulting in a \$370,000 reduction in charges for 41 home care treatments during the study. These data indicate that home therapy is less costly and is as effective as in-hospital therapy.

In all the studies discussed above, only three [Penketh et al. (1982), Wall et al. (1983), Donati et al. (1987)] planned the antibiotic treatment prospectively. In the remaining studies, each acute exacerbation of infection was treated as it occurred. The only major study to date which has calculated the differences in efficacy between the two modes of treatment is that by Pederson et al. (1987). In this study, the annual mortality rate of cystic fibrosis patients with chronic *Pseudomonas aeruginosa* lung infection fell from 10-20% in the years 1970-1975 to 1-2% in 1985, after the centre studied switched from only treating acute exacerbations of infection to administering 2-week intravenous courses every 3-4 months.

So far it has been demonstrated that Gudex's cost utility estimate of ceftazidime treatment of cystic fibrosis is sensitive to a range of assumptions

concerning the efficacy of of ceftazidime treatment relative to those of established treatment. The way in which the lack of definition of the term established treatment may itself affect the cost and efficacy of antibiotic treatment has also been discussed. In the next section, the acceptability of Gudex's assumptions are further discussed by considering the placebo-controlled antibiotic trials to date and examining how effective antibiotics have in fact been in treating cystic fibrosis patients.

#### **5.4 Benefits of Placebo-Controlled Studies**

To analyse Gudex's assumption that ceftazidime treatment has no effect on patient disability and survival and only slightly reduces patient distress, the benefits resulting from antibiotic treatment in the placebo controlled antibiotic trials of cystic fibrosis were calculated. An extensive literature search revealed ten placebo-controlled antibiotic trials dating back to 1977. For each of these ten antibiotic trials, information was gathered on the efficacy of the active treatment and the improvement or deterioration in parameters which constitute components of the Taussig and Shwachman scores was noted. Where possible, the precise effects of antibiotic treatment on the two clinical scores were estimated, thereby allowing us to make some inferences on Gudex's assumptions.

Three of the ten antibiotic trials [Wientzen et al. (1980), Gold et al. (1987) and Regelman et al. (1990)] compared active versus placebo treatment for single acute pulmonary exacerbations of cystic fibrosis. In all three trials, patients showed evidence of improvement during active treatment.

## (a) Wientzen et al. (1980)

Wientzen et al. (1980) performed a double-blind evaluation of intravenous tobramycin therapy versus placebo to test the hypothesis that antibiotic therapy was not as important as intensive chest physiotherapy in treatment of acute exacerbations. Eleven children were given 2 mg/kg of tobramycin every 8 hours as a one-hour continuous infusion. Therapy was continued daily until the time of discharge from the hospital or until persistence or worsening of symptoms required breaking the code. Eleven patients were given placebo. The active group fared better. Clinical responses were recorded as satisfactory in all eleven children given tobramycin and in seven of the eleven given placebo, though it is not stated what constitutes a satisfactory clinical response. The interpretation of the results was clouded by the fact that patients with more severe disease were randomized to the placebo group.

No patient given placebo demonstrated improvement in pulmonary function studies, whereas 4 of 6 children given tobramycin showed a 15% or greater improvement in at least 2 of the 3 tests performed [vital capacity (VC), forced expiratory volume in 1 second (FEV<sub>1</sub>) and peak expiratory flow rates (PEFR)]. Of these, only vital capacity is a component of the Taussig score. At least a 15% improvement in this parameter would lead to at least a 2 or 4 point improvement in the Taussig score. However, it is also likely that tobramycin therapy would have increased FEV<sub>1</sub> as a percentage of total VC, another of the pulmonary function tests. This would also increase the Taussig score. This is the best we can do. Without any precise figures, we cannot make precise estimates of the improvements in the Shwachman and Taussig scores. Chest roentgenograms showed no consistent changes in most patients in either group during the course of treatment with placebo or tobramycin. Tobramycin treatment was associated with a 1 logarithm or greater decrement in *Pseudomonas sputum* concentrations in the sputum of



6 of 7 patients, although this occurred in only 2 of 8 patients given placebo. Tobramycin treatment was associated with a 2 logarithm or greater decrement in *Pseudomonas* sputum concentrations in the sputum of 3 of 7 patients, although this occurred in only 1 of 8 patients given placebo. This parameter can perhaps be equated with component I of the Taussig score (sputum production and / or cough). As a result tobramycin treatment may have increased the Taussig score by 1 in this component as well.

(b) Gold et al. (1987)

Gold et al. (1987) conducted a randomized trial of ceftazidime versus placebo in patients with cystic fibrosis hospitalized for acute respiratory exacerbations. Sixteen patients were given ceftazidime; fifteen patients were given placebo, three of whom dropped out. Active treatment consisted of 200 mg/kg/day over a 14 day period. There were no significant differences in the rate of improvement of symptom score, weight gain, or pulmonary function between the two treatment groups. There was no difference in the course during the 6-24 months after the study period. The authors argue that, intravenous antibiotics are not essential in the management of all acute respiratory exacerbations of mild to moderate severity in patients with cystic fibrosis.

Results of sputum cultures were similar in both groups; most patients were infected with both *Pseudomonas aeruginosa* and *Pseudomonas cepacia*. The clinical responses after the 16 episodes were treated with ceftazidime were all rated as showing improvement in that the patients were discharged within 14 days, having returned to their usual state of health. In 10 of the 12 episodes treated with placebo, clinical responses were also rated as showing improvement. When the 16 ceftazidime-treated episodes are compared with

the 12 placebo-treated episodes (10 cures and 2 failures), no significant differences were seen in any outcome measure. The average weight gains between admission and discharge in the ceftazidime and placebo groups were 2.6% and 2.1% respectively, not enough to alter the Taussig score (though they may increase the Shwachman Score), but indicating a reduction in patient disability. The mean number of days taken to peak improvement in clinical scores in the 2 groups were 6.0 and 6.4 days, respectively. No differences in the rates of improvement in the total symptom score or in scores for cough, dyspnea, or anorexia were observed, implying that ceftazidime had no positive effect on patient distress over and above that of placebo. Similarly, the rate of improvement in daily spirometry was the same in both groups. Analysis of the results of complete pulmonary function tests also indicated no statistically significant differences, either in the increments in FEV<sub>1</sub>, FEF<sub>25%-75%</sub> or FVC or in the proportions of patients with at least a 10% increase in pulmonary function. The mean percentage change in % predicted value of FEV<sub>1</sub>, FEF<sub>25%-75%</sub> and FVC was +19%, +27.7% and +17.8% in the ceftazidime group, and +11.5%, +22.9% and +4.8% in the placebo group. Without knowing the pretreatment percentages, we cannot estimate the effects on the Taussig score, but it is clear that ceftazidime did not lead to a significant improvement over and above that of the placebo. Bacteriologic outcomes differed significantly in the 2 treatment groups. Ceftazidime reduced the colony counts of *Pseudomonas aeruginosa* by more than 3 log<sub>10</sub> cfu/ml in over 55% of episodes. No such change was observed in the placebo group. Ceftazidime had no effect on *Pseudomonas cepacia*. All patients were followed up for 6 to 24 months after discharge. The hospitalization rates subsequent to the acute exacerbation were similar: 0.96 and 0.79 admissions per patient-year in the ceftazidime and placebo groups respectively (p greater than 0.1).

(c) Regelman et al. (1990)

Regelman et al. (1990) record the performance of 12 cystic fibrosis patients who had been stratified to receive either parenteral tobramycin and ticarcillin (n=7) or placebo (n=5), in addition to aerosol therapy and chest physiotherapy. Both groups had initially received 4 days of bronchodilating aerosols and chest physiotherapy. Treatment (average daily doses of tobramycin and ticarcillin were 10.5 mg/kg and 317 mg/kg respectively) lasted 14 days.

The study provides strong evidence of the benefits of antibiotic therapy for patients suffering from single acute pulmonary exacerbations of cystic fibrosis. Significantly (p less than 0.01) greater improvements were observed in FVC, FEV<sub>1</sub> and FEF<sub>25-75%</sub> in the antibiotic group compared to the placebo group. In the antibiotic group, the FVC improved by 13% predicted, from 77% to 90%; the FEV<sub>1</sub> improved by 16% predicted, from 54% to 70%; and the FEF<sub>25-75%</sub> improved by 20% predicted, from 31% to 51%. This compares with no significant changes in FVC, FEV<sub>1</sub> and FEF<sub>25-75%</sub> in the placebo group. Antibiotic treatment increases the Taussig score by 3 points, solely as a result of the improvement in the forced vital capacity parameter. FEV<sub>1</sub> as a percentage of VC increases from 70% before treatment to 78% at the end of the 14-day treatment period. This does not increase the Taussig score, but is an indicator of reduced patient disability. Likewise, the 20% improvement in FEF<sub>25-75%</sub> does not lead to an increase in the Taussig score, but suggests that antibiotic treatment does lead to a reduction in patient disability. The antibiotic group showed significantly (p less than 0.01) greater reductions in log<sub>10</sub> colony-forming units (cfu) of *Pseudomonas aeruginosa* per gram of sputum. In each of the antibiotic-treated patients, a greater than 99% (greater than 2 log<sub>10</sub> cfu) reduction in the cfu/g sputum of *Pseudomonas aeruginosa* was observed. None of the placebo-treated patients experienced such a reduction. The degree of decrease in log<sub>10</sub> cfu *Pseudomonas aeruginosa*/g sputum correlated

significantly ( $p$  less than 0.001) with the degree of improvement in FVC, FEV<sub>1</sub> and FEF<sub>25-75</sub>%. In both groups, there was a significant ( $p$  less than 0.0001) decrease in quantity of sputum produced by an average of 12.6g/12h, but no difference between antibiotic and placebo groups was observed. Sputum production and/or cough is component I of the Taussig Score, worth 3 points. It may be that both antibiotic treatment and placebo treatment improve the Taussig score, but we cannot estimate by how much without any guide-lines. A significant ( $p = 0.0001$ ) increase in weight by 2.6kg (5.3%) was observed in both the antibiotic and placebo groups, but no significant difference was observed between the 2 groups. This improves the Taussig score by 2 points in both groups and also increases the Shwachman Score.

The mean Brasfield score improved by 26% within the antibiotic group, compared to 5% within the placebo group, indicating improved X-ray findings. This also improves both the Taussig and Shwachman scores.

Table 5.9 (page 175) summarizes the benefits in each of the three studies [Wientzen et al. (1980), Gold et al. (1987) and Regelman et al. (1990)] resulting from the treatment of each episode of acute exacerbation as it occurs. All three studies showed some improvement during active treatment. In addition, they all showed improvement in parameters which affect the Shwachman and Taussig scores. It was not clear from any of the three studies, however, if antibiotic treatment reduced inpatient stay or improved the survival prospects of the patients.

Seven additional placebo controlled antibiotic trials were found in the literature. They all report the results of planned prospective treatment of cystic fibrosis patients and, as such, they form a distinct group. The earliest of these trials was the double blind study by Park et al. (1977).

## (d) Park et al. (1977)

The authors divided 22 cystic fibrosis patients into 2 groups according to age, sex and pulmonary status. Group A was given oral cloxacillin (50 mg/kg/day) and group B, a placebo, over a 12 month period. The remaining cystic fibrosis treatment methods remained unchanged. Ten of the eleven patients receiving active treatment improved or remained stable and one showed deterioration. The respective figures for patients receiving placebo treatment were six and five. We are not given any specific data concerning sputum volume and colour, cough, physical examination, ESR, chest radiograph, pulmonary function tests and blood gas analysis, the parameters measured by the authors. As a result, we cannot estimate whether antibiotic treatment improves the two clinical scores. However, the authors conclude that the data indicates that there is less progression of the pulmonary component of cystic fibrosis in patients who received continuous cloxacillin.

## (e) Loening-Baucke et al. (1979)

Loening-Baucke et al. (1979) recorded the effects of oral administration of cephalexin over a 2 year period. Every 4 months, 50 mg/kg/day of cephalexin was alternated with placebo in a group of 17 cystic fibrosis patients who served as their own control subjects. The authors observed fewer acute respiratory infections (48 v 63), respiratory infections requiring antibiotics (25 v 53) and respiratory infections requiring hospitalization during the periods that patients received cephalexin. Acute respiratory illnesses were defined as increased cough and sputum production, decrease in physical activity, with or without fever, and / or change in roentgenographic findings in chest. These seem to be acceptable indicators of patient disability and distress. Forty-eight

cases of acute respiratory infections occurred during the periods that patients received cephalexin, compared to 63 during the placebo period. This suggests a prevention of a deterioration in health status amongst patients receiving active treatment. Cephalexin appeared to have the greatest effects upon patients initially infected with *Staphylococcus aureus* with or without simultaneous infection with *Haemophilus influenzae* ( $p$  less than 0.05).

More rapid weight gain was observed during cephalexin treatment in 16 of the 17 patients. This will have a positive effect on the Shwachman and Taussig scores, but we cannot estimate by how much as we are not given any absolute figures. The height gain of patients given cephalexin was also greater than those given placebo. This will have a positive effect on the Shwachman score, but once again any absolute improvements cannot be estimated. The initial Shwachman scores were similar in all groups (range 55-85) despite the fact that patients initially infected with *Pseudomonas aeruginosa* (median age 8.6 years) were older than patients not infected with *Pseudomonas aeruginosa* (median age 5.7 years). Patients initially infected with *Pseudomonas aeruginosa* ( $n=11$ ) showed a decrease in the total Shwachman score, whereas those patients not infected with *Pseudomonas aeruginosa* ( $n=6$ ) appeared to improve during the 2-year period. These differences were significant ( $p$  less than 0.05), even though they only represent small changes in the clinical score of 3 to 6 points (absolute figures are not shown by authors). We are not given any information on the Shwachman scores during the placebo period. Without the full absolute figures we cannot calculate the effect of the change in the Shwachman score on Gudex's approximations, but it does contradict her assumption that antibiotic therapy has no effect on patient disability.

Of the pulmonary function tests performed on 14 patients, 10 remained stable. The FVC and FEV<sub>1</sub> were significantly improved during cephalexin treatment in patients infected by *Haemophilus influenzae* ( $p$  less than 0.05). Again, without absolute figures, or any information on the placebo group, we

cannot estimate the effect improved pulmonary functioning has on the Taussig or Shwachman scores and hence estimate any effects on Gudex's assumptions.

(f) Hodson et al. (1981)

Hodson et al. (1981) present a placebo controlled antibiotic trial of inhaled antibiotics. It was a double-blind randomised cross-over trial of carbenicillin and gentamicin versus placebo. The authors randomly allocated 20 patients to 6 months' treatment with aerosol antibiotic and 6 months' treatment with placebo. Active treatment consisted of 1g of carbenicillin and 80mg of gentamicin, twice daily, for 6 months.

In terms of patient preferences, 14 of the 17 patients who completed the trial favoured the antibiotic period and 3 patients were uncertain. The assessments of the clinician favoured the antibiotic preparation in 12 cases and the placebo in 1; in 4 cases he was uncertain. There were significant improvements in FEV<sub>1</sub> ( $p$  less than 0.001), FVC ( $p$  less than 0.02) and PEF<sub>R</sub> ( $p$  less than 0.001) during the active preparation. No patient showed a significant improvement in any of the pulmonary function tests when taking the placebo. Furthermore, the frequency of acute hospital admissions was reduced during aerosol treatment although the difference was not significant because of the small numbers involved

Let us study the pulmonary function test results in more detail. Mean FEV<sub>1</sub> was 92ml per patient for the antibiotic group (1566/17) and 76ml per patient for the placebo group (1300/17). Mean FVC was 156ml per patient for the antibiotic group (2656/17) and 136ml per patient for the placebo group (2314/17). Therefore, mean FEV<sub>1</sub> was 59% of mean FVC for the antibiotic group, and mean FEV<sub>1</sub> was 56% of mean FVC for the placebo group. This is

the only data on the benefits of antibiotic treatment which we can use and the higher proportion does not change the Taussig score, though it is an indicator of reduced patient disability under the antibiotic regimen.

(g) Kun et al. (1984)

Kun et al. (1984) compared the benefits from the twice daily inhalation of 20mg of nebulised gentamicin over 2 years with the inhalation of a nebulised saline mixture in 29 children with cystic fibrosis. The majority of the children had minimal or mild lung disease on entry to the study.

The authors recorded no significant difference in antibiotic usage, days in hospital or clinical symptoms between the two regimes, though the subjects with *Pseudomonas aeruginosa* in sputum showed significantly less deterioration in lung function over the 2 years while using gentamicin aerosol. Antibiotic usage was calculated by the formulation of and conversion into an antibiotic score. To obtain an overall antibiotic score, one day's therapy of cotrimoxazole (trimethoprim-sulphamethoxazole) or tetracycline was scored as 1, oral flucloxacillin combined with amoxycillin or erythromycin was scored as 3, oral chloramphenicol as 5 and intravenous antibiotics as 7. Clinical symptoms were estimated by the parents of children under the age of 10 and the patients themselves over that age recording on a continuum scale with semantic cues the quality of the cough, the amount of the cough, the amount of sputum produced and its type as well as any changes in cough and sputum.

Patients on gentamicin showed a slower deterioration in pulmonary function. The mean percentage change in FEV<sub>1</sub> over the 2 years was 0 in the gentamicin group and -6 in the saline group. In terms of FEF<sub>25-75%</sub>, the mean percentage change was -2 in the gentamicin group and -6 in the saline



group. Hence there was a milder, though not significant, deterioration in patient disability in the gentamicin group, though we cannot estimate the effect on the Taussig score as we are not given any information on the vital capacity of the patients. For those with *Pseudomonas aeruginosa* on entering the study however, there were significant differences between the gentamicin and saline regimes (change in FEF<sub>25-75</sub>,  $p$  less than 0.05; change in FEV<sub>1</sub>,  $p$  less than 0.02). There was no statistically significant differences for the 21 subjects without *Pseudomonas aeruginosa* at the beginning of the study. There was also no significant difference between the 2 treatment regimes in preventing the development of *Pseudomonas aeruginosa*.

(h) Carswell et al. (1987)

Carswell et al. (1987) present a double-blind cross-over comparison of oral flucloxacillin and nebulized aminoglycoside versus double placebo. The study was composed of 6 children with cystic fibrosis who had persistently had *Pseudomonas aeruginosa* isolated from their respiratory tract. Active treatment lasted for a month and consisted of oral flucloxacillin, 25 mg/kg of bodyweight/dose and nebulized tobramycin.

The results of the study indicate improved pulmonary function and reduced disability at the end of the month of active treatment. We are not told the initial FEV<sub>1</sub>, FVC and PEF<sub>R</sub> scores. However, we are told that FEV<sub>1</sub> was the only respiratory function testing which was statistically significant. Figure 1 in the Carswell et al. paper indicates that FEV<sub>1</sub> was approximately 61% at the end of the active period and approximately 57% at the end of the placebo period. Assuming FEV<sub>1</sub> improved during treatment (which we can infer from the discussion), the Taussig score might have increased at the end of the active treatment simply as a result of the improvement in FEV<sub>1</sub> as a

percentage of vital capacity. (Without the absolute figures, this is the best we can do). We are also told that all 6 of the peak expiratory flow rates and 5 out of 6 of the forced vital capacity changes showed higher values at the end of the active treatment period than at the end of the placebo period. The mean FVC (standard deviation) and PEFR (standard deviation) at the end of the active treatment period were 66.5(28)% predicted and 75.8(36)% predicted respectively. The respective figures for the placebo period were 63.8(23)% predicted and 72.8(36)% predicted. Assuming the two sets of scores were similar prior to the two types of treatment, they will have no effect on the Taussig score. However, we can say that patient disability has been reduced as the discussion of the Carswell et al. paper states that there was a significant improvement in respiratory function in the treatment group and respiratory function is, arguably, one indicator of patient disability: "The trial indicates that significant improvement in respiratory function can be produced in ambulant children with cystic fibrosis by a regimen of oral flucloxacillin and nebulized aminoglycoside" (page 359). In terms of sputum production, another parameter within the Taussig Index, no consistent changes were detected after nebulised tobramycin.

(i) Jensen et al. (1987)

Jensen et al. (1987) carried out a prospective double-blind placebo-controlled study of colistin inhalation. Forty cystic fibrosis patients (20 males and 20 females, with a mean age of 14.2 years), who were infected with chronic bronchopulmonary *Pseudomonas aeruginosa*, were treated over a period of 3 months. Active inhalation consisted of one million units of colistin dissolved in 3 ml of sterile water, twice daily.

The authors argue that "Colistin treatment was superior to placebo treatment in terms of a significantly better clinical symptom score, maintenance of pulmonary function and inflammatory parameters" (page 831). There was a significant difference in the completion rates of the study (18 in the active group, 11 in the placebo group).

Mean FVC fell from 86% of normal at the beginning of the study to 79% of normal after 90 days for the colistin group. The respective figures for the placebo group were 89% and 71%. Therefore, in this study, antibiotic treatment slows the deterioration in pulmonary function, rather than leads to any improvement. Even though the mean fall in FVC was significantly smaller in the colistin treated group as compared to the placebo group ( $p$  less than 0.05), the reduction in the Taussig score is the same for both groups - the Taussig score falls by 2 points in both cases. Mean FEV<sub>1</sub> fell from 71% at the beginning of the study to 60% after 90 days for the colistin group. The respective figures for the placebo group were 79% and 62%. The fall in mean FEV<sub>1</sub> was less pronounced in the colistin group, but the difference observed was not significant and the Taussig score is not affected by the exercise if FEV<sub>1</sub> is taken as a percentage of FVC. Of the parameters white blood cell count, erythrocyte sedimentation rate and orosomucoid, only the change in orosomucoid during the study period was significantly in favour of colistin treatment. The authors conclude that their study "...illustrates that colistin inhalation reduces the deterioration in wellbeing and pulmonary function, and also reduced the inflammatory response that otherwise occurs after completion of a course of intravenous anti-pseudomonal therapy" (page 837).

(j) Stead et al. (1987)

The study by Stead et al. (1987) provides strong evidence that antibiotic therapy reduces the disability of cystic fibrosis patients. In a crossover trial, aerosol ceftazidime was compared with aerosol gentamicin plus carbenicillin and with saline (placebo), each given for 4 months to 13 cystic fibrosis patients infected with *Pseudomonas aeruginosa*.

The three alternative treatments were (1) 1g of ceftazidime, (2) 80mg (2ml) of gentamicin solution and 1g of carbenicillin or (3) 3.5% sodium chloride solution. Each treatment was given twice a day. The authors were unable to demonstrate any difference in efficacy between the 2 antibiotic regimens, but both patients on aerosol carbenicillin plus gentamicin and those on ceftazidime showed an increase in body weight and improved lung function. Also, hospital admissions were less frequent during the study year than during the previous year. Of the 13 patients who completed the study, 4 required a total of 5 admissions to hospital during the study year, compared to 10 requiring a total of 16 similar admissions in the previous year).

The authors show that patients improved their PEF, FEV<sub>1</sub> and FVC scores whilst taking the active preparations compared to pretreatment values and to values achieved during the saline period. All but one of the differences were statistically significant, the exception being the case of FVC during ceftazidime treatment compared with saline. The median FVC of the patients on entry to the study was 53% of the predicted value. If we assume that the median and mean FVC scores are similar, then the predicted FVC is 4.62 litres (from Table II in the Stead et al. paper). Therefore, FVC was 64% of predicted value at the end of the ceftazidime period, 63% of predicted value at the end of the gentamicin/carbenicillin period and 58% of predicted value at the end of the saline period. As a result, the Taussig score increases by 2 points at the end of both the ceftazidime and gentamicin/carbenicillin periods and does not

change during the saline period. There was a 14% increase in peak expiratory flow [PEF (litres/min)] during the ceftazidime period and a 13% increase in PEF during the gentamicin/carbenicillin period, compared to a 6% increase in PEF during the saline period. Though this has no effect on the Taussig score (since PEF is not a component of the Taussig score), it is a good indicator that antibiotic treatment improves pulmonary function and reduces patient disability. Nine of the 13 patients showed at least a 20% increase in mean FEV<sub>1</sub> during one or both antibiotic treatment periods compared to the value on entry to the study. FEV<sub>1</sub> was 53% of vital capacity at the beginning of the study, 58% of vital capacity at the end of the ceftazidime period (leading to a 2 point increase in the Taussig score), 58% of vital capacity at the end of the gentamicin/ carbenicillin period (leading to a 2 point increase in the Taussig score) and 55% of vital capacity at the end of the saline period (leading to no change in the Taussig score). Bodyweight increased by 2.9kg during the ceftazidime period (leading to a 2 point increase in the Taussig score), by 2.8kg during the gentamicin/carbenicillin period (leading to a 2 point increase in the Taussig score) and by 1.7kg during the saline period (leading to no change in the Taussig score). Sputum purulence (colour), arguably an indicator of patient distress, was reduced to 2.9 during the ceftazidime period (on a 0-5 scale), compared with 3.3 during the gentamicin/carbenicillin period and 3.4 during the saline period. Sputum volume (production), an indicator of both disability and distress was reduced to 2.3 during the ceftazidime period (on a 0-5 scale), compared to 2.4 during the gentamicin/carbenicillin period and 2.9 during the saline period. Sputum production and/or cough, component I of the Taussig score, is given 3 points, so it may be that antibiotic treatment has increased the Taussig score in this component as well. (Once again, the absence of pre-treatment data precludes a more precise estimate).

At the end of the study, 8 of the 13 patients stated a preference for ceftazidime of the 3 treatments, and 4 preferred gentamicin and carbenicillin. One patient had no preference.

Table 5.10 (page 176) summarizes the benefits in each of the seven studies [Park et al. (1977), Loening-Baucke et al. (1979), Hodson et al. (1981), Kun et al. (1984), Carswell et al. (1987), Jensen et al. (1987) and Stead et al. (1987)] resulting from the planned prospective antibiotic treatment of cystic fibrosis. In all but one of the seven studies [Kun et al. (1984)], the patients showed some improvement during antibiotic treatment. In three of the seven studies [Loening-Baucke et al. (1979), Hodson et al. (1981) and Stead et al. (1987)], there is evidence that antibiotic treatment reduces patient days in hospital. In five of the studies [Loening-Baucke et al. (1979), Hodson et al. (1981), Carswell et al. (1987), Jensen et al. (1987) and Stead et al. (1987)], there were improvements in parameters which affect the Shwachman and Taussig clinical scores. None of the studies indicated any evidence that antibiotic treatment improves the survival prospects of cystic fibrosis patients.

**Table 5.9 : Benefits of Treatment of Each Episode of Acute Exacerbation in Placebo Controlled Antibiotic Trials of Cystic Fibrosis Treatment**

Author	Number of Patients	Improvement During Treatment	Reduction in Days in Hospital	Improvement In items which Affect Shwachman / Taussig Scores (Indicators of Disability)	Improvement In Survival
Wientzen et al (1980)	11 Placebo, 11 Active	Yes	Not Known	FEV <sub>1</sub> , FVC, PEFR, sputum production	Not known
Gold et al (1987)	15 Placebo, 16 Active	Yes	No	appetite, cough, dyspnea, FEV <sub>25-75%</sub> FEV <sub>1</sub> , FVC, pulse, respirations, weight	Not known
Regelmann et al (1990)	5 Placebo, 7 Active	Yes	Not known	FEV <sub>25-75%</sub> , FEV <sub>1</sub> , FVC, sputum production, weight, X-ray findings	Not known

**Table 5.10 : Benefits of Planned Prospective Treatment in Placebo Controlled Antibiotic Trials of Cystic Fibrosis Treatment**

Author	Number of Patients	Improvement During Treatment	Reduction in Days in Hospital	Improvement In Items which Affect Shwachman/Taussig Scores (Indicators of Disability)	Improvement In Survival
Park et al (1977)	11 Placebo, 11 Active	Yes	Not known	Not known	Not known
Loening-Baucke et al (1979)	17 Placebo, 17 Active	Yes	Yes	cough, FEV <sub>1</sub> , FVC, height, physical activity, pulmonary exacerbations, sputum production, weight, X-ray findings.	Not Known
Hodson et al (1981)	20 Placebo, 20 Active	Yes	Yes	FEV <sub>1</sub> , FVC, PEF	Not known
Kun et al (1984)	29 Placebo, 29 Active	No	No	None	No
Carswell et al (1987)	6 Placebo, 6 Active	Yes	Not known	FEV <sub>1</sub> , FVC, PEF	Not known
Jensen et al (1987)	20 Placebo, 20 Active	Yes	Not known	Clinical symptom score	Not known
Stead et al (1987)	Ceftazidime: 13 Placebo, 13 Active	Yes	Yes	FEV <sub>1</sub> , FVC, PEF, sputum production, weight	Not known
	Gentamicin/ Carbenicillin: 13 Placebo, 13 Active	Yes	Yes	FEV <sub>1</sub> , FVC, PEF, sputum production, weight	Not known



### 5.5 Summary and Conclusion

In this chapter, it has been demonstrated that Gudex's cost utility estimate of ceftazidime treatment is sensitive to a range of assumptions concerning the efficacy of ceftazidime treatment. In addition, there has been a discussion of how the lack of definition of the term established treatment may itself affect the cost and efficacy of established treatment. In the main body of the chapter, the placebo controlled antibiotic trials of cystic fibrosis treatment were reviewed which allowed us to estimate how effective antibiotics in fact are in treating cystic fibrosis patients. From this analysis and the summary of the results, we can see that there is little evidence for Gudex's assertion that antibiotic treatment has no significant effect on patients' level of disability. In 7 of the 10 studies [Park et al. (1977), Wientzen et al. (1980), Hodson et al. (1981), Carswell et al. (1987), Gold et al. (1987), Stead et al. (1987) and Regelman et al. (1990)], there were improvements in the pulmonary function tests which make up a large component of the Taussig score, and which a recent study by Orenstein et al. (1989) show to be highly significantly associated with the quality of well-being of cystic fibrosis patients. Of these 7 studies, only the study by Gold et al. (1987) showed no significant differences between the antibiotic and the placebo groups. In the 3 other studies [Loening-Baucke et al. (1979), Kun et al. (1984) and Jensen et al. (1987)], antibiotic treatment slowed the deterioration in pulmonary function and there were significant differences between the two groups of patients. Indeed, even with the limited information we are given in most of the papers, there is strong evidence that the two clinical scores increase as a result of antibiotic treatment in 3 of the trials [Wientzen et al. (1980), Stead et al. (1987), Regelman et al. (1990)] and in a subgroup of patients in one other trial [Loening-Baucke et al. (1979)]. In defence of Gudex, none of the studies indicated any improvement in the survival prospects of the cystic fibrosis patients, which was shown in

the first section to radically alter the cost effectiveness of cystic fibrosis treatment.

The main problem we come across when attempting to convert the data we are given in the papers to a generic health-related quality of life score, such as the Rosser Valuation Matrix, or even to disease-specific ratings, such as the Shwachman and Taussig Scores, is the limited amount of information we have to work on. The study by Hodson et al. (1981), for example, only gives data on 3 pulmonary function tests (FEV<sub>1</sub>, FVC and PEFR), and none of these are components of the Shwachman Score. A second problem that we face when attempting to convert the information we are given into indexes is that identical parameters have been presented by different studies in different ways which cannot strictly be compared. For example, Wientzen et al. (1980) give us information on the improvement in pulmonary function scores, whilst Jensen et al. (1987) present the pre-treatment and post-treatment percentages. Finally, we have to overcome the problem that the prognostic scores available turn continuous variables (such as the pulmonary function percentages) into discrete variables, and hence may not adequately reflect any real improvement or deterioration in patient health-related quality of life. For example, an increase in VC from 69% to 70% would lead to a 2 point increase in the Taussig Score, indicating an improvement in patient health-related quality of life. However, an increase in VC from 70% to 79% would leave the Taussig Score unchanged, indicating that patient health-related quality of life remained unchanged. Clearly, a continuous scale would be preferable in measuring such parameters. A more detailed discussion of these issues will be presented in Chapter 7.

Ideally, we would like information on a number of parameters which could easily be converted into Rosser Disability/Distress Categories and which would comprehensively measure the health-related quality of life of cystic fibrosis patients. Parameters which would reflect patient disability would

include pulmonary function tests, eg, FVC, FEV<sub>1</sub>, FEV, PEFR, general activity (work/school), weight, oxygen saturation, pulmonary radiograph, sputum production, bacterial counts in sputum, infection markers in blood and serology. Parameters which would reflect patient distress would include cough, sputum production, dyspnea, malaise, appetite and attitude. These parameters could be measured on continuous scales and perhaps be given appropriate weights. Such information would allow us to make an overall assessment of the health-related quality of life of cystic fibrosis patients, and assist us in measuring the benefits of antibiotic and other treatments. Where studies do use disease-specific scales, such as the Shwachman and Taussig clinical scores, researchers should present all the relevant data (pretreatment and posttreatment scores). Not only would this allow us to make a more reasonable assessment of the benefits of the studied treatments, but it would make it easier for others to convert the information into generic scores (such as the Rosser Classification) and hence make cross-programme comparisons easier.

Nevertheless, despite the paucity of information, we do have enough data to be able to say that antibiotic treatment can have a significant effect on patients' level of disability. The paper by Stead et al. (1987), for example, gives us enough information to be able to say that ceftazidime treatment led to at least a 5-8 point increase in the Taussig score, and that is solely based on the components of the Taussig score which the authors have measured. It is probable that, if all the components had been measured, the increase in the prognostic score would have been much greater.

In conclusion, it has been shown that there is little evidence to prove Gudex's assumption that ceftazidime treatment has no effect on the disability of cystic fibrosis patients, and that her cost utility estimate of cystic fibrosis treatment is sensitive to a whole range of assumptions that she makes.

CHAPTER 6

COSTS OF ANTIBIOTIC TREATMENT OF CYSTIC FIBROSIS

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## 6.1 Introduction

In the Gudex study, no information is provided about the derivation of the cost estimates for each of the seven medical procedures. It is not clear which forms of treatment were costed, which costs were included in the final total cost estimates and how they were arrived at. This chapter aims to show that specifying an exact cost for a medical programme can be misleading when researchers do not provide any details about the form of medical treatment being costed and the range of costs calculated. The chapter begins with an identification of the range of costs a medical programme might incur and some of the problems that might arise in the calculation of those costs. A case study of the costs of hospital acquired infection is presented to illustrate the components usually calculated by the medical and health economics literature. The main body of the chapter then presents an analysis of Gudex's cost estimate for one of the seven medical procedures, her £250 annual cost estimate for the ceftazidime treatment of cystic fibrosis patients. It is shown that there are different modes of ceftazidime treatment, each with very different cost structures which can affect Gudex's conclusions.

## 6.2 Costs - Identification and Problems

Economists usually use the concept of *opportunity cost* when estimating the costs of a health care programme, that is costs are defined as the benefits foregone by investing in a project rather than the simple financial outlay. Levin (1975) defines the cost of a health care programme as "representing that set of social sacrifices associated with any particular choice among social-policy alternatives" (page 98). As an illustration, let us consider the example of unpaid volunteers in a hospital. Their work may not add to the hospital's

wage bill, but their labour still represents a true cost of the running of the hospital. They contribute to the hospital's output, and their labour is a cost to society in the sense that it could have been more productively used in another sector during that time or spent on leisure activities. This leads economists to divide the costs of a health care programme between *direct costs* and *indirect costs*. Direct costs represent the resources purchased directly to run the health care activity. This category may be subdivided into *fixed costs* which do not vary as output varies, for example, depreciation costs and rent, and *variable costs* which are directly related to output and include wages and costs of equipment. Indirect costs represent the element of indirect consumption of resources in the production process, for example the value of lost earnings by patients who are unable to work. A further category of costs are the *intangible* or *psychic costs*, defined by Drummond et al. (1987) as "costs borne externally to the health sector, patients, and their families" (page 22). This refers to the element of pain or grief experienced by patients and their families and friends. Economists usually shy away from valuing such costs and, as a result, implicitly set them equal to zero across disease groups.

Even after the relevant costs of a health care programme have been identified, a number of problems arise when one attempts to value them. Warner and Luce (1982) describe the problem facing economists who try to measure research and development costs when such costs are an integral component of the medical programme. Drummond (1981) describes the problems involved in the division of costs when the production process produces the joint use of resources (joint production). In addition to these rather technical problems, there are other areas of difficulty. For example, there is the problem of valuing the time lost by patients and others (such as families, friends, volunteers) through illness. The arguments for and against using earnings losses as a measure of lost production are presented by Drummond et al. (1986). The same authors criticise the common use of

average hospital costs per day as unrepresentative of a particular treatment or department of interest. The further issue of reducing future costs to present values was presented in Chapter 4, together with a discussion of the need for sensitivity analyses of alternative discount rates.

### 6.3 Case Study of the Costs of Hospital Acquired Infection

To evaluate the cost components commonly calculated by economists and medical researchers, a case study of the costs of hospital acquired infection was carried out. A literature search revealed eleven studies which, in one form or another, had calculated the cost of nosocomial infection. All eleven had measured (at least some of) the direct costs associated with infection, whilst only one [Dixon (1985)] attempted to measure the indirect costs.

Beyt et al. (1985) attempted to audit the bills and medical records of 26 randomly selected American patients with hospital-acquired infections over a six month period. The sites of infection of the selected patients fell into 4 major groups: urinary tract, lower respiratory, surgical wound infections and bacteremia. Additional costs were estimated jointly by an infection control practitioner and an infectious disease consultant. The costs included were room 'charges' for increased length of stay; medications including antibiotics; laboratory tests including culture and sensitivity reports, antibiotic levels and toxicity studies; respiratory therapy; x-ray; additional surgical procedures; supplies, and other 'charges'. The authors did not calculate any health care labour costs, nor any indirect costs due to nosocomial infections. The final annual cost of nosocomial infections was estimated at \$484,723 for the 270-bed acute care general hospital, of which medications and supplies were the most significant components.

Davies and Cottingham (1979) estimated the costs to the National Health Service of nosocomial bacterial infections. The cohort studied was a group of 345 orthopaedic patients. Of these, 29 patients (8.4%) became infected, excluding patients discharged in the first 48 hours. They were then matched with control patients from the same cohort. The sites of infection of the 29 patients were: wound, chest, urinary tract, wound and urinary tract and general or three site. The authors calculated total inpatient costs, extra microbiology cost, total antibiotic costs, costs of visits to GP's and costs of visits by nurses for each of the patients. Costs attributable to loss of productive activity were not calculated. The final estimate of excess costs attributable to infection was £775 per infected patient (1978 prices), of which at least 97% was accounted for by the increased length of stay.

The study by Dixon (1985) attempts to estimate the economic and financial burdens that result from respiratory tract infections in the United States. Respiratory tract infections were defined as any acute infection involving the upper or lower respiratory tract (for example, otitis media and pneumonia). Where possible, noninfectious components of these illnesses and the chronic sequelae of some acute infectious diseases were excluded from the analysis. The author estimated both direct and indirect costs. The direct costs included were hospital 'charges', physician fees, costs of diagnostic tests and the costs of antimicrobial treatment. These were estimated at \$470 million (1984 prices). Of this total sum, physician fees accounted for approximately 9 percent. Indirect costs were estimated by calculating the loss in income of employed persons who miss work because of infection. The estimated loss in wages alone stood at \$9 billion per year. The author does not clarify what proportion of this total was due to nosocomial respiratory infections, but he states the possibility that the indirect loss of income may equal the total direct costs of these infections.



An earlier study by the same author [Dixon (1978)] calculated the overall impact of infections on hospital care in the United States. The study divided infections into those acquired in the community and those acquired whilst in hospital. The incidence of the latter was based on the infection estimates reported by National Nosocomial Infections Study (NNIS) hospitals in 1976. Pathogens were categorised into 4 groups, whilst the anatomic sites of infection were combined into 7 major groups. Using unpublished Center for Disease Control studies, the author derived an estimate of 6 million days attributable to the prolongation of stay for nosocomial infections. When the extra costs of medication, specialised or intensive care and infection isolation requirements were considered, a 1977 estimate of \$4.8 billion for treating infectious diseases was arrived at. This figure included the costs of treating community-acquired infections, but excluded physicians fees and all indirect costs.

A French study of the costs of hospital acquired infections was carried out by Girard et al. (1983). This study calculated the costs of hospital acquired infections for 61 neonates. The observed infections were divided into the following sites: umbilicus, eye, mouth, nose and upper respiratory tract, intestine, urinary tract, and blood. The costs considered by the study were the extra inpatient costs resulting from prolonged stay, the costs of additional biological and radiological tests, the cost of medical and surgical procedures, and the costs of drugs, IV fluids and human milk. No indirect costs were calculated by the authors. The additional average costs resulting from infection were 6000 French Francs, 93% of which was the consequence of a 28% increase in the length of stay.

Green and Wenzel (1977) considered the differences in duration of hospital stay and hospital bills between matched patients with and without acquired postoperative wound infections. Six operation sites were focussed on: appendectomy, cholecystectomy, bowel resection, total abdominal

hysterectomy, caesarean section and coronary artery bypass graft. No mention was made of which costs were calculated, although the authors imply that only the direct costs to the surgical patient were included. We are told however that postoperative wound infections increased the average hospital bill from \$705.51 to \$1,394.48 following appendectomy, from \$2,139.12 to \$2,582.13 following cholecystectomy, from \$2,823.58 to \$4,414.77 following colon resection, from \$1,096.44 to \$1,885.29 following total abdominal hysterectomy, from \$775.30 to \$1,302.80 following caesarean section and from \$4,939.82 to \$7,542.50 following coronary artery bypass graft.

Haley et al. (1981) estimated the cost of hospital acquired infection in 3 hospitals that differed in size, administrative characteristics and patients' financial status. The infection types included in the study were urinary tract infections, bloodstream infections, lower respiratory tract infections, surgical wound infections and a group of unspecified 'other' infections. The authors divided costs as follows: costs of prolonged hospitalization, antibiotics, bacteriologic cultures, other laboratory services, roentgenograms, respiratory therapy and miscellaneous services. Physicians' fees and costs attributable to loss of productive activity were excluded from the estimates. It should be noted that the study did not make a distinction between 'costs' and 'charges'. The 3 hospitals showed similar results in terms of prolonged hospitalization and increased charges.

An analysis of the characteristics that distinguish high and low cost nosocomial infections was carried out by Pinner et al. (1982). Information was based on 215 infections in 183 study patients. Of these, 92 were urinary tract infections, 5 were bacteremia infections, 29 were lower respiratory tract infections, 69 were surgical wound infections and 20 were other infections. The cost components included the cost due to routine 'charges' caused by extended hospital stay or by hospital transfer and supplementary costs attributable to the infection, such as laboratory fees, antibiotic costs and x-rays.

Health care labour costs and indirect costs were not included in the estimates. The authors estimated an average cost per infection of \$590.

Rose et al. (1977) report a retrospective study of the hospitalization costs of 40 patients with hospital-acquired bacteremias at the University of Virginia Hospital. A comparison was made with 40, similarly aged, matched and uninfected patients. The study focussed on patients with hospital acquired bloodstream infections. Only the cost of hospitalization was considered; physicians' fees, radiology bills and all indirect costs were excluded. The cost of hospital stay for bacteremic patients (mean \$6,692) was estimated to be three times that of the matched controls.

Scheckler (1980) reports a prospective assessment of the costs of 123 nosocomial infections in 104 patients over a three-month period. Of the 123 infections, 65 were urinary tract infections, 26 were surgical wound infections, 17 were pneumonia infections and 15 occurred in other sites. Scheckler breaks down the costs of infections into increased length of stay; diagnostic services, including intravenous fluids used to treat the nosocomial infection and therapeutic services, such as inhalation therapy, physical therapy, surgery, etc, used to treat the infection. Data on physicians' fees were not available; therefore they were not recorded. In addition, indirect costs were not taken into account. The author calculated an average hospital charge of \$636 for each nosocomial infection, about half of which was accounted for by prolonged length of stay.

The final study found in the literature search which attempted to calculate the cost of hospital acquired infection was carried out by Spengler and Greenough (1978). This study focussed on 81 patients with nosocomial bacteremia. Total room costs and total laboratory charges were included in the study, but no labour or indirect costs were taken into account. The authors showed an average excess of approximately \$3,600 in direct hospital costs for infected patients.

The above studies are typical of cost analyses in the medical literature. The indirect and intangible costs of a treatment or an illness are usually ignored, and even the full range of direct costs are often not calculated. Apart from the identification and valuation problems outlined in the previous section, researchers often take a narrow viewpoint at the outset of a study and ignore the costs of a programme or an illness to patients and to society. Clearly, many of the studies above take the viewpoint of attempting to calculate the costs of nosocomial infections to a hospital. Patient and societal concerns, such as losses in earnings and productivity, are ignored. In effect, ignoring such costs underestimates the true costs of the infections. In addition, a methodological error of many American studies is to confuse charges with costs. They are not identical and researchers should attempt to use true costs where possible.

#### **6.4 Analysis of Gudex's Cost Estimate for Antibiotic Treatment of Cystic Fibrosis**

Gudex estimated the annual cost of ceftazidime treatment for cystic fibrosis patients at £250. No information was provided concerning the derivation of the cost estimate. Neither was it clear which cost components were included in the final estimate. This section attempts to show that this figure may be misleading, and that alternative assumptions concerning the mode of antibiotic treatment and cost components affect the final cost utility results.

We learnt in Chapter 5 that there are different methods of treating cystic fibrosis patients with antibiotics. The antibiotic may be delivered through intravenous, inhaled or oral routes. Patients may be treated in hospital or, alternatively, at home. Treatment may be planned prospectively or each acute exacerbation may be treated as it occurs. What is not clear from the Gudex study is which mode of treatment has been used as the basis for cost

estimation. Clearly, this will affect the final results of the study as each mode of treatment has different cost implications.

Few previous studies have estimated the costs of alternative methods of treating cystic fibrosis patients with antibiotics. Gilbert et al. (1988) estimated a saving of £29,098 a year from a home intravenous service, based solely on the cost of inpatient accommodation (assumed to be £81.37 per day). They also calculated a saving of up to £110 per week for the families of 13 cystic fibrosis patients, because of reduced travelling expenses to hospital and because earnings were not lost. Kuzemko and Williams (1986) estimated that the approximate hospital and home care costs (excluding antibiotics) in the UK for 30 patients amounted to £36,000 and £1,680 respectively. Donati et al. (1987) estimated significant differences in the charges billed to 41 home patients and 41 matched hospital patients. The estimates were \$10,000 (\$600 per day) for the home care patients and more than \$18,000 (\$1,000 per day) for the hospitalized patients, resulting in a \$370,000 reduction in charges for 41 home care treatments during the study. The results indicated that home therapy was less costly and as effective as in-hospital therapy.

To determine the confidence with which we can use Gudex's results, the costs associated with alternative modes of antibiotic treatment were compared. The sources of information were the 10 placebo-controlled antibiotic studies discussed in Chapter 5 [Park et al. (1977), Loening-Baucke et al. (1979), Wientzen et al. (1980), Hodson et al. (1981), Kun et al. (1984), Carswell et al. (1987), Gold et al. (1987), Jensen et al. (1987), Stead et al. (1987) and Regelman et al. (1990)]. For each study, a note was made of the antibiotic(s) administered, the method of delivering the antibiotic, whether patients were treated for each acute exacerbation of infection as it occurred or whether treatment was planned prospectively, the average daily dose and frequency of treatment, the duration of treatment, the antibiotic costs per patient per day/course, the hospital hotel costs per patient per day/course, the

administration/equipment costs per day/course, total costs per patient per day/course and total costs per patient per course/per year.

Daily antibiotic costs and course of treatment antibiotic costs were calculated from the July 1990 edition of MIMS. Hospital hotel costs were assumed to be £140 per day in 1990 prices (M. Malek, personal communication). This figure included the cost of all staff salaries, drugs, equipment and overheads such as heating and lighting. Administration / equipment costs were calculated using the median figures estimated by Davey et al. (1990). This study had comprehensively estimated the recent costs of materials used in IV administration. The items costed were IV lines, syringes, needles, water for injection, saline, hepsalush/hepsal, gloves and mediwipes. The cost of a nebuliser was based on the 1991 hospital price for a Medicare 'Parkneb', and it was assumed that each one was discarded at the end of each trial.

Table 6.1 (page 194) summarizes the costs of the 3 trials which compared active versus placebo treatment for single acute exacerbations of cystic fibrosis [Wientzen et al. (1980), Gold et al. (1987) and Regelman et al. (1990)]. The patients in all three trials were treated intravenously and in hospital. Treatment in the latter two trials lasted for 14 days; Wientzen et al. (1980) do not clarify the duration of their trial. Only Regelman et al. (1990) state the average bodyweight of their sample of patients (49kg), and this has been used as the standard to calculate average daily doses of antibiotics in the other two trials. The main difference in costs was in the daily antibiotic costs per patient. The daily cost of tobramycin of £10.73 in the study by Wientzen et al. (1980) was one ninth of the daily cost of ceftazidime of £97.02 in the study by Gold et al. (1987). The total costs per patient per course were £3,365.60 in the Gold et al. (1987) study and £2,833.74 in the Regelman et al. (1990) study. If a 14 day duration is also assumed for the study by Wientzen et al. (1980), the total costs per patient per course would have been £2,203.74.

Table 6.2 (page 195) summarizes the costs of antibiotic treatment in the seven placebo controlled trials which planned treatment prospectively [Park et al. (1977), Loening-Baucke et al. (1979), Hodson et al. (1981), Kun et al. (1984), Carswell et al. (1987), Jensen et al. (1987) and Stead et al. (1987)]. The patients in all seven trials were treated with either inhaled antibiotics or oral antibiotics, or both. All seven trials were located in the homes of the patients. The duration of the trials varied between 1 month [Carswell et al. (1987)] and 2 years [Kun et al. (1984)]. For the studies which reported average daily doses of antibiotics in mg/kg and did not report the average bodyweight of their patients, the average bodyweight of 49kg reported by Regelman et al. (1990) was used. When all the antibiotic, hospital and administration costs were annualized, the range of costs varied between £651.01 for 50 mg/kg/day over a 12 month period [Park et al. (1977)] and £7,341.71 for 1g ceftazidime, twice daily over a 4 month period [Stead et al. (1987)], an elevenfold difference.

In terms of planning antibiotic treatment prospectively, oral prophylaxis appears to be cheaper than inhaled prophylaxis because equipment costs are avoided. The main difference in costs between the treatment of each acute exacerbation as it occurs and planned prospective treatment was in the daily hospital hotel costs incurred by the former mode of treatment. It must be stated at this point however that great care should be taken when making such cost comparisons, if no associated evidence is available concerning the relative efficacy of the modes of treatment. If planned prospective antibiotic treatment were shown to prevent regular episodes of acute exacerbations of infection, then there would be a strong case for antibiotic treatment to be planned in such a manner. A review of the case records of the six cystic fibrosis patients receiving planned prospective treatment in Dundee suggests that such treatment is successful in preventing acute exacerbations of infection. All six patients had at least one emergency admission in the year preceding planned prospective treatment. They were then placed on a course

of regular treatment with intravenous ceftazidime. Three of the patients also received regular nebulized tobramycin. In the one to two years following initiation of planned prospective treatment, none of the six patients were admitted to hospital for treatment of an acute exacerbation. This suggests that planning treatment prospectively is successful in avoiding the hospitalisation of cystic fibrosis patients. What this study cannot state however is that regular prophylaxis is the most cost effective method of treating cystic fibrosis patients with antibiotics. Stronger evidence is required concerning the success of such treatment in preventing acute exacerbations of infection before such a hypothesis can be proven.

This study has illustrated the variety of methods in which cystic fibrosis patients can be treated with antibiotics. Each mode of treatment differs in its costs and efficacy. It is clear that, despite the difficulties that exist in comparing alternative methods of treatment, Gudex's annual cost estimate of £250 for ceftazidime treatment of cystic fibrosis patients is unrealistically low. This appears to be the case even after the cost estimate is inflated to 1990 prices [which have been used as the basis for the cost estimations in Tables 6.1 (page 194) and 6.2 (page 195)]. A cost of £250 in 1986 prices is equivalent to a cost of £331 in 1990 prices using the Retail Price Index. It is unlikely that antibiotic and equipment costs increased by much more than the rise in general prices over the years 1986-1990. A cost estimate of £331 is approximately half of the lowest annual cost estimate of the placebo controlled trials [Park et al. (1977)] and just 4.5% of the highest cost estimate [Stead et al. (1987)].

An increase in the annual cost estimate of ceftazidime treatment of cystic fibrosis reduces the relative cost effectiveness of the procedure, if all Gudex's other assumptions remain unchanged. However, Chapter 5 concluded that Gudex's assumptions concerning the efficacy of ceftazidime treatment were sensitive to a whole range of assumptions. Therefore, it would be inappropriate to use Gudex's health-related quality of life estimates when



assessing the cost effectiveness of the procedure. What we can say however is that it is unclear how Gudex has arrived at her cost estimate, and that an extensive cost analysis of alternative methods of treating cystic fibrosis patients with antibiotics has shown this estimate to be unrealistically low. A plea is made to researchers to explain how their cost estimates were arrived at.

In tables 6.1 and 6.2 (pages 194-195), only the direct costs of antibiotic treatment were incorporated into the final cost estimates. As explained in the previous section, this underestimates the true costs of treatment to society. Most of the cystic fibrosis patients in the placebo controlled studies were children or young adults. It is likely that most of them were still in education whilst receiving treatment and hence, the cost to society in terms of lost earnings or lost productivity would be relatively small. However, other indirect costs of treatment were likely to have arisen. For example, the parents of the patients may have incurred travelling expenses or lost time from their own work whilst attending to the needs of their children. Incorporating the indirect costs of antibiotic treatment of cystic fibrosis patients into the cost estimates in Tables 6.1 and 6.2 (pages 194-195) would widen further the differences with Gudex's own cost estimate and increase the reservations we have about Gudex's results.

**Table 6.1 : Cost of Treatment of Each Episode of Acute Exacerbation in Placebo Controlled Antibiotic Trials of Cystic Fibrosis Treatment**

Author	Drug	Dose	Route	Frequency	Antibiotic Costs Per Patient Per Day	Hospital Hotel Costs Per Patient Per Day	Admin / Equip Costs Per Patient Per Day	Total Costs Per Patient Per Day	Total Costs Per Patient Per Course
Wientzen et al (1980)	Tobramycin	2 mg/kg	Intravenous	Every 8 hours	£10.73*	£140	£6.68	£157.41	Not known
Gold et al (1987)	Ceftazidime	200 mg/kg/day	Intravenous	Every 6 hours over 14 days	£97.02*	£140	£3.38	£240.40	£3,365.60
Regelmann et al (1990)	Tobramycin and Ticarcillin	10.5 mg/kg tobramycin, 317 mg/kg ticarcillin	Intravenous	Divided doses over 14 days	£53.96	£140	£8.45	£202.41	£2,833.74

\* Using the average bodyweight of the group of patients studied by Regelmann et al (1990) of 49kg

**Table 6.2: Cost of Planned Prospective Treatment in Placebo Controlled Antibiotic Trials of Cystic Fibrosis Treatment**

Author	Drug	Dose	Route	Frequency	Antibiotic Costs Per Patient/ Course	Hospital Hotel Costs Per Patient/ Course	Admin / Equip Costs Per Patient/ Course	Total Costs Per Patient/ Course	Annual Costs Per Patient
Park et al (1977)	Cloxacillin	50 mg/kg/day	Oral	Divided doses over 12 months	£651.01*	Not Applicable	Not Applicable	£651.01	£651.01
Loening-Baucke et al (1979)	Cephalexin	50 mg/kg/day	Oral	Divided doses over 12 months	£570.53*	Not Applicable	Not Applicable	£570.53	£570.53
Hodson et al (1981)	Carbenicillin and Gentamicin	1g of carbenicillin, 80mg of gentamicin	Inhaled	Twice daily over 6 months	£1,715.50	Not Applicable	£109.24	£1824.74	£3,554.48
Kun et al (1984)	Gentamicin	20 mg	Inhaled	Twice daily over 2 years	£576.70	Not Applicable	£113.98	£690.68	£690.68
Carswell et al (1987)	Aminoglycoside and Flucloxacillin	40 mg of aminoglycoside, 25 mg/kg of flucloxacillin	Inhaled and Oral	Divided doses over 1 month	£440.70*	Not applicable	£95.78	£536.48	£5,466.34
Jensen et al (1987)	Colistin	1 million units	Inhaled	Twice daily over 3 months	£329.40	Not applicable	£99.86	£429.26	£1,450.61
Stead et al (1987)	Ceftazidime	1 g	Inhaled	Twice daily over 4 months	£2,376	Not Applicable	£101.48	£2,477.48	£7,341.71
	Gentamicin and Carbenicillin	80 mg of gentamicin and 1 g of carbenicillin	Inhaled	Twice daily over 4 months	£1,128	Not Applicable	£107.96	£1,235.96	£3,565.42

\* Using the average bodyweight of the group of patients studied by Regelman et al (1990) of 49kg

# CHAPTER 7

## DISCUSSION

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## 7.1 Summary

This thesis has endeavoured to examine the incorporation of health status measurement techniques into the economic appraisal of health care programmes and the application of such techniques. The increasing use of health state utility values and quality adjusted life years in deciding how health care resources should be allocated was analysed. Particular attention was focussed on two patient groups, those who had undergone hip and knee joint replacement surgery, and results of one important study [Gudex (1986)].

The thesis began by introducing the techniques commonly used in the economic appraisal of health care programmes, namely cost analysis, cost minimisation analysis, cost benefit analysis, cost effectiveness analysis and cost utility analysis (Chapter 1). The position of health status measurement within such a framework was explained.

Chapter 2 provided a detailed synopsis and exposition of the techniques which have been used to measure health status. Five broad approaches were outlined: the willingness to pay approach, decision analytic techniques, the use of existing utility values available in the medical literature, a range of measurement techniques (the rating scale technique, the standard gamble approach, the time trade-off approach, the equivalence method, ratio scaling) and the use of health status indices. Examples were provided to illustrate how these techniques are used in practise. Particular attention was focussed on one health status index, the Rosser-Kind Classification of Illness States, because of its prominence in the field of Health Economics and its importance to this thesis. The latter part of Chapter 2 explained how cardinal utility values have been derived from these health status measurement techniques and used as a method of assessing preferences for alternative health states within a single weighted measure, the quality adjusted life year.

In Chapter 3, the Rosser-Kind Classification was used to estimate the preoperative and postoperative health-related quality of life of patients who had undergone hip and knee joint replacement surgery. This chapter had four aims. First, to compare the use of the Rosser-Kind Classification with detailed questionnaires as tools of measurement in health-related quality of life estimates. Second, to test for the reliability of using retrospective data as opposed to prospective data when estimating the improvements in health-related quality of life in patients who had undergone hip and knee joint replacement surgery. Third, to calculate the scale of change in health-related quality of life in the two groups of patients, with QALY's used as the method of estimation. Fourth, to use the results to estimate the time period over which the maximum improvements in health-related quality of life are achieved. The interviewed patients were divided into two groups, a control group and a much larger retrospective group, who were matched in terms of age, sex and operation site.

The control group patients were interviewed twice, once prior to their operations and once at three months following their operations. Amongst these patients, the Rosser-Kind Classification was found to be as good a health status indicator as much more detailed questionnaires. In addition, it was found that retrospective data could be used with some degree of confidence when estimating the improvements in health-related quality of life in patients who have had hip replacements. However, such data should only be used with caution when estimating the improvements in health-related quality of life in patients who have had knee replacements. It was argued that further research is required before any generalisations could be made concerning the acceptability of retrospective data. A third result from this group of patients was that there were significant improvements in health-related quality of life following both hip and knee joint replacement surgery.

The retrospective group of patients were interviewed once only, at three months, one year or two years following their operations. Each interview was divided into two sections. The first section asked patients about their health-related quality of life at that point in time, and the second section asked patients about their health-related quality of life prior to their operations. As was the case for the control group, there was strong agreement between the subjects' estimates of their health-related quality of life (based on the Rosser-Kind Classification) and the derived estimates (based on their responses to the detailed questionnaires). There were noticeable improvements in the health-related quality of life of both sets of patients following surgery, with results suggesting that the highest Rosser-Kind rating score is achieved after the first year following knee replacement surgery and after the second year following hip replacement surgery.

Chapter 4 performed an extensive sensitivity analysis on widely-quoted cost utility calculations [Gudex (1986)] for seven medical procedures: CAPD, haemodialysis, treatment of cystic fibrosis with ceftazidime, kidney transplantation, shoulder joint replacement surgery, scoliosis surgery for idiopathic adolescents and scoliosis surgery for neuromuscular illness. Gudex's main arguments were outlined and the underlying assumptions of her study discussed. The chapter then presented a sensitivity analysis of Gudex's conversion of the health outcome data (she had selected from the medical literature) into the Rosser-Kind Classification. In addition, her assumptions concerning the survival period / life expectancy following each of the seven medical procedures and the 5% discount rate used were also varied. Only two of the seven cost utility estimates, those for CAPD and haemodialysis, were shown to be robust after the three sets of sensitivity analyses, whilst the cost utility estimates for shoulder joint replacement surgery and surgery for scoliosis secondary to neuromuscular illness were shown to be sensitive to all three variables. The cost utility estimates of renal

transplantation, ceftazidime treatment of cystic fibrosis and scoliosis surgery for idiopathic adolescents were shown to be sensitive to two of the three variables. Moreover, sensitivity analyses of all three variables produced results which altered Gudex's cost utility rankings of the seven medical procedures.

Chapter 5 conducted a more in depth analysis of Gudex's cost utility estimate for one of the seven medical procedures, cystic fibrosis treatment with ceftazidime. After a detailed sensitivity analysis of Gudex's assumptions concerning the procedure, the chapter then proceeded to demonstrate that these assumptions are not borne out by the medical literature. Rather, the placebo controlled antibiotic trials to date suggest improvement in patient well-being and reduced patient disability, which contradicts Gudex's arguments and radically alters her final cost utility estimate.

Chapter 6 followed on from Chapter 5 by analysing Gudex's cost estimate for ceftazidime treatment of cystic fibrosis. The chapter showed that it is misleading for researchers to specify exact costs for medical programmes when they do not provide corollary information on what exactly is being costed. Using the same placebo controlled trials that were analysed in Chapter 5, it was shown that there are different modes of ceftazidime treatment, each with different cost structures which affect Gudex's final cost estimate and her conclusions.

The thesis raises a number of issues which require more detailed discussion. These fall into four broad areas. First, the use of disease-specific and generic health status indices within the economic evaluation of health care programmes. Second, the implications of discounting future costs and benefits to their present values. Third, the use and abuse of the QALY concept for allocating scarce health care resources. Fourth, the problems involved in collecting original health state utilities. Each of these issues shall be discussed in detail, after which will follow a list of lessons which have been learnt from



the thesis as a whole and which health care evaluators would do well to incorporate into their studies.

## 7.2 Health Status Indices

A number of issues arise when using health status indices or output measures in economic evaluations of health care programmes, whether they are disease-specific measures, such as the Shwachman and Taussig scores, or more generic measures, such as the Rosser Classification and the Karnofsky Index of Performance Status.

### 7.21 Concept of health

It is important to understand that health status measurement is in itself a difficult process. By its very nature, it is a complex, multidimensional process and it is laden with value judgments. In 1947, the World Health Organization defined health as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1947). The English dictionary defines health as "a sound state of body or mind; freedom from disease; bodily conditions; wish of health and happiness." Using these definitions, it is clear that disease-specific scales do not tend to measure health status in its complete sense. Neither do they usually claim to. Rather, indices such as the Shwachman and Taussig scores are helpful for classifying the initial disease of patients as well as providing quantitative estimations of outcomes. They are of great benefit to analysts, but they should be used as health status 'indicators' and not health status 'measures'. Chapters 4 and 5 demonstrated that it may be inappropriate to base resource allocation decisions on information derived from these disease-specific scales, since it is

likely to be intermediate output effectiveness data, which cannot easily be converted into QALY's. In addition, few general or generic health status indices actually cover all aspects of health-related quality of life. Instead, they tend to cover those aspects which the authors claim to adequately reflect health status or which the confines of the study allowed to be measured. Of the health status indices covered in Chapter 2, not only the older measures (Karnofsky Index of Performance Status) but also some of the more recent and widely-quoted measures (Nottingham Profile, Euroqol Instrument) fail to adequately cover all aspects of health-related quality of life: physical health, mental health, everyday functioning in social activities, everyday functioning in role activities and general perception of well-being. As discussed in Chapter 3, the Rosser-Kind Classification also fails to measure some aspects of health-related quality of life, such as role fulfilment, and fails to account for the dynamics of disease.

### 7.22 Acceptability of Measures

A second issue which arises for discussion when using health status indices in economic evaluations of health care programmes is the acceptability and validity of the chosen measure. Spitzer et al. (1981) argue that a good health-related quality of life index should have the following 10 attributes: "It should be simple, which means it should be short, easy to understand, to remember, to administer and to record. It should be comprehensive, covering an adequate range of the different dimensions of quality of life. Its content should be compatible with views of the community and the dimensions should be identified empirically from patients, healthy people, physicians, and other providers. It should be quantitative. It should be applicable in many situations with as few restrictions as possible related to

factors such as age, sex, occupation and category of chronic disease. It should be formally validated before being recommended for wide or general use. It must be acceptable to those measuring (particularly clinicians) and to those measured. It should be sensitive to changes in the health status of persons measured. It should discriminate well among groups of people with demonstrably different levels of quality of life. The new index should be plausible; the resulting scores should be consistent with other measures of health status, clinical status or life stage." (Page 587).

Sackett et al. (1977) lay down seven prerequisites for credible health indices. First, they should be comprehensive. They should encompass social, emotional and physical function. Second, they should be positively orientated and be able to identify good or even excellent function. Third, they should be generally applicable to free-living populations. Fourth, the indices should be sensitive enough to detect important changes in health status or function. Fifth, the health status measurements should be able to be made quickly, at reasonable cost, and without embarrassment or offence. Sixth, the individual and group reproducibility of the health measurements repeated at short intervals should be high. Seventh, the measurements should be amenable to index construction.

The Rosser-Kind Classification exhibits all the qualities and meets all the prerequisites described by Spitzer et al. (1981) and Sackett et al. (1977). It is fairly straightforward to understand and record, comprehensive, empirically identified, quantitative, widely applicable, validated, acceptable (based on the available evidence), able to discriminate between patients with different levels of health-related quality of life, plausible, reproducible and amenable to index construction. However, a doubt remains over its ability to pick up small changes in the health-related quality of life of some patients. For example, a person confined to a wheelchair following an accident might slowly improve his/her health-related quality of life as defined by the World Health

Organization, but might also remain confined to Rosser Disability Category VI. As discussed in the previous section, the disease-specific scales used in the studies, from which Gudex obtained her health outcome information (Chapters 4 and 5), are not comprehensive measures of health-related quality of life and, by themselves, could not be used to make across-programme comparisons.

### 7.23 Appropriate Subjects

A third issue for discussion is the appropriate number and combination of subjects whose preferences form the basis of the valuations for such health status indices. Drummond et al. (1987) argue that informed members of the general public, who truly understand what health states are like, and community representatives, are the appropriate subjects. They do not recommend the use of patients as the source of utilities as this method restricts the measurement to one health state utility per subject. Of the health status indices covered in Chapter 2, only eight [Breslow (1972), Patrick et al. (1973), Kaplan et al. (1976), Sackett et al. (1977), Kind et al. (1982), Torrance et al. (1982), Bulpitt and Fletcher (1990) and Euroqol Group (1990)] conducted initial surveys which assigned preference values to alternative health states. In only two of these eight studies [Patrick et al. (1973), Kind et al. (1982)] were the subjects medically qualified. The subjects in the remaining studies were either randomly selected members of the general public, members of a general practice, parents of school children or psychology college students. The use of non-medically qualified persons to assign utility values to alternative health states has been criticised by Mooney (1986), because such persons are likely to have great difficulty in understanding concepts of health. If we accept that medically qualified people are in a position to assign utility

values to alternative health states, a question remains over the appropriate size and composition of the sample of subjects. Doctors and nurses may differ between themselves over utility values for alternative health states. Kind et al. (1982) found that in their sample, doctors placed relatively less emphasis on the importance of death. In their analysis of the relative importance that 48 British rheumatologists placed on 10 commonly measured clinical variables in 50 sets of patient data, Chaput de Saintonge et al. (1988) found that the doctors showed little agreement over which patients had improved and which had not. It seems therefore that the selection of a sample to make utility valuations is of great importance. The size and composition of such a sample entails value judgments over whose preferences are appropriate to make the valuations. There are no right or wrong answers. Rather, the best suggestion would be to test utility valuations over as many subjects as possible, including diverse groups of subjects, and over periods of time. If these valuations differ greatly, then it should be explicitly stated that a judgment has been made that the preference values of a certain group are the most appropriate.

#### **7.24 Method of Valuation**

A fourth issue for discussion when using health status indices in economic evaluations of health care programmes is the method in which preference values for alternative health states are obtained. Two main approaches of obtaining estimates are available, the questionnaire approach and the interview approach. Drummond (1981) argues that one problem with the questionnaire approach is that individuals may deliberately overstate their valuations if they know the purpose of the exercise. In addition, question wording and ordering and extraneous factors may bias responses. The

interview approach has the advantage of correcting subjects' misunderstandings and inconsistent answers. However, it may place more pressure on subjects to respond to questions which they would otherwise fail to answer. Questioning or interviewing medically qualified professionals, as Rosser and Kind (1978) did to obtain relative preference values for the Classification of Illness States, should overcome these problems. Nevertheless, it is always difficult to ensure that any one of a number of extraneous variables do not systematically bias a subject's responses.

In the joint replacement study (Chapter 3), the interview approach was used as the method of assessing the quality of life of the patients. In each interview, the patient was asked a set of previously formulated questions. The majority of the questions offered a number of alternative answers, from which the patients were asked to choose one. This approach was selected because it was the most convenient, and because it was feared that a questionnaire approach would have a lower compliance rate. An attempt was made not bias each subject's responses.

### 7.25 Ordinal and Cardinal Scales

A fifth issue which arises when using health status indices in the economic evaluation of health care programmes is the different scaling methods of indicating or measuring health status. Essentially, these fall into two broad categories: *ordinal scales* and *cardinal scales*. Ordinal scales tell us that one unit has more of a property than does another unit. In the case of health status indices, a person or a group of people deem that one health state is better or worse than another health state. (Note, value judgments are entailed in this decision). No meaningful numerical inferences can be made about the differences between the health states. Cardinal scales do allow us to

make meaningful numerical inferences about the differences between different health states and fall into two categories: *interval scales* and *ratio scales*. Interval scales tell us that one unit differs by a certain amount of a property from another unit. However, no real meaning is assigned to the zero or the endpoint on interval scales. Ratio scales do have true zero points and allow us to say that one unit has so many times as much of a property as does another unit. For example, ratio scales allow us to say that a score of 4 is twice as good as a score of 2 and one half as good as a score of 8.

Ideally, we would like health status indices to exhibit the ratio scaling quality. This would allow us to make meaningful comparisons between alternative health states. However, of all the health status indices covered in this thesis, disease-specific as well as generic, only the Rosser-Kind Classification of Illness States assigned utility values to alternative health states using the ratio scaling method. Most of the remainder are ordinal scales which do not allow us to say that a patient with health state  $a$  is  $x$  times better or worse than a patient with health state  $b$ . Let us illustrate this point with two examples.

The health status index developed by Grogono and Woodgate (1971) was described in Chapter 2. It assesses patients with respect to 10 activities, each of which receive a score of either 1, 0.5 or 0, representing normal, impaired or incapacitated respectively. The results are then transformed into a 0-1 index by dividing the total score by 10. Using this index, it is possible to say that a score of 1 for each of the functions is better than a score of 0.5, which in turn is better than a score of 0. However, we are not able to say how much better a normal state is than an impaired state, or how much better an impaired state is than an incapacitated state. We certainly cannot say that it is twice as good. The reason for this is that the authors have assigned arbitrary values (1, 0.5 and 0) to three of many possible levels of disability without any prior evidence that utility values for these health states conform to an interval or

ratio scale. Likewise, it may be misleading to quote an overall score using this index, since people may make cardinal conclusions from ordinal scale data. That is not to say that ordinal scales are of no use to the field of health status measurement. They certainly are helpful, but they are not appropriate for inclusion in quality adjusted life year data.

A second illustration is the NIH Clinical Score developed by Taussig et al. (1973) and described in Chapter 5. This is a disease-specific scale which evaluates chronic pulmonary disease in cystic fibrosis patients. It assigns patients a score out of 100, three-quarters of which is placed on the pulmonary component. The NIH Clinical Score is a good example of an ordinal scale which makes value judgments about which attributes contribute to a patient's health-related quality of life, weights the relative importance of each attribute and adds the ratings for each attribute to form a total score. The scale may assist evaluators in concluding that a patient with an NIH score of 70 has a better health-related quality of life than a patient with an NIH score of 60. However, they are not able to say how much better that quality of life is. That would attribute to the scale a property possessed only by ratio and interval scales. For health economists who would like to convert information available in disease-specific ordinal scales, such as the NIH Clinical Score, into quality adjusted life years, this raises many problems. Assumptions have to be made concerning the utility weight placed on each increment of the ordinal scale, that is to say it has to be stated explicitly that a year of life with an NIH Clinical Score of  $x$  is equivalent to  $y$  quality adjusted life years. More often than not, this would be too complex a task, and health economists would find it more straightforward to measure the health-related quality of life of patients using a ratio-scaled index such as the Rosser-Kind Classification and then convert this information into quality adjusted life years.

There are a number of additional assumptions which ordinal health status indices or ad hoc numerical scales make. First, many of them simply add



scores for a number of attributes which are assumed to measure health-related quality of life. This implicitly assumes that each attribute is an equally important determinant of health-related quality of life. The Shwachman-Kulczycki Score, which assesses the health-related quality of life of cystic fibrosis patients and was covered in Chapter 5, weights general activity, physical examination, nutrition and X-ray findings equally. Of the generic health status indices, the Grogono-Woodgate Index [Grogono and Woodgate (1971)] assumes equal importance for 10 activities, the Ability Index [Izsak and Medalie (1971)] assumes equal importance for 15 activities, the Activities of Daily Living Index [Katz and Akpom (1976)] places equal importance on six functions and it appears that the Spitzer QL-Index [Spitzer et al. (1981)] assumes equal importance for five activities. Other generic health status indices assume equal weights for different attributes which are themselves subdivided and then combined in different permutations [Torrance et al. (1982), Euroqol Group (1990)]. Assuming equal importance for different functions in this way is debatable. For example, Grogono and Woodgate (1971) argue that physical suffering and recreation are equally important determinants of health-related quality of life. It could be argued, in response, that physical suffering is by far the greater concern to the patient.

A second assumption which many ordinal health status indices make, and which follows on from the first assumption, is that by simply adding the scores together for different functions, they assume that each function is independent. Though this may be the case, it is more likely that the scores for different health functions are highly correlated. For example, with respect to the Shwachman-Kulczycki Score, it is quite likely that an improvement in the general activity element of the score is associated with an improvement in the physical examination element. As a result, a minor fluctuation in a patient's health-related quality of life might lead to a spurious inflation or deflation of the overall score. Alternatively, a fluctuation in a patient's

health-related quality of life might not be picked up at all because of the limited number of functions chosen to measure it.

In addition to the assumptions of exhaustiveness, equal importance and mutual exclusivity, a third assumption of many ordinal health status indices is that they can measure changes in continuous variables, using discrete and often unequal categories. The example was given in Chapter 5 of the Taussig NIH Clinical Score which is divided into a number of categories. The score increases by 2 points if the vital capacity of cystic fibrosis patients increases from 69% to 70%, but remains unchanged if the vital capacity of the patients increases from 70% to 79%. Clearly, this unequal subdivision of categories of a scale may not adequately reflect any real improvement or deterioration in patient health-related quality of life. Continuous categories of scales or categories which are subdivided into equal steps would be preferable in measuring such parameters.

Finally, many ordinal health status indices are mistakenly analysed using parametric statistical tests, such as means and standard deviations. This was Gudex's error when she estimated the mean Shwachman and Taussig score for the 27 patients studied by Boyle et al. (1976). Parametric statistical tests should not be used as ordinal data only tell us the rank order of scores and there is no proof that intervals between the increments on the scales are equal in any true sense. This can be illustrated with a quote from Andersen (1990): "When steps on a measurement scale are not known to be of equal length, values from different patients ought not to be added to form a mean. It is also impermissible to estimate the SD. An analogy may illustrate the problem. Suppose eight athletes are available for a 4 x 100 m relay for men in the Olympics. Their qualifications are constant, but have been measured on an ordinal scale only. It is accordingly known that A is less than B is less than C is less than D is less than E is less than F is less than G is less than H. The team ABCD ought accordingly always to defeat team EFGH, but what are the

chances of ABCH in competition with DEFG? The tradition in clinical research is to symbolize the classes of an ordinal scale with 1-2-3-4-5-6-7-8. This rule would make team ABCH the winner, because  $1 + 2 + 3 + 8$  is less than  $4 + 5 + 6 + 7$ . Suppose the seven athletes were Olympic-class track stars and the eighth (= H) a 54-year-old overweight smoker with arthritis! Now it is likely that team DEFG would win. The reason is that the translation  $H = 8$  fails to reveal that the distance from G to H is much larger than any other. H ought perhaps to be 13 or 127? Calculation of mean and SD from data on an ordinal scale requires some translation. No matter which is used, the absence of a benchmark means the introduction of some unverifiable assumptions. Conclusions accordingly rest upon them. This uncertainty is intolerable, because alternatives exist without such problems. The median and fractiles (e.g. percentiles or quartiles) should be used to indicate central tendency and dispersion whenever data are on ordinal scales." (Pages 179-180).

### 7.26 Conversion into Generic Scales

The sixth and final issue for discussion which has arisen in the use of health status indices in this thesis, and which was touched upon in Chapter 4, is the conversion of information from disease-specific scales or ad hoc numeric scales into generic health status indices, such as the Rosser-Kind Classification.

Across-programme output measures aid health economists by offering guidance on the relative benefits to be derived at the margin by putting resources into one programme or another [Williams (1989)]. However, obtaining information on all medical conditions using such generic outcome measures would be a tremendous task, and it is often easier to convert information available from disease-specific outcome measures into across-

programme outcome measures. This conversion process has the advantages of avoiding setting up new studies and using large data sets already in existence. In addition, it avoids expecting health service professionals to adopt a new outcome measure which they are not familiar with and which they might perceive to be crude.

In Chapter 4, sensitivity analyses were conducted on Gudex's conversions of data from a number of disease-specific outcome measures into the Rosser-Kind Classification. Despite the advantages of the conversion process, and appreciating the constraints faced by Gudex, a number of difficulties with this approach come to mind. First, it is imperative that the correct disease-specific scale is selected as a comprehensive measure of each clinical condition. We learnt in Chapter 5 that the Shwachman and Taussig scores are not comprehensive measures of health-related quality of life. Under such circumstances, health economists or clinicians may have to choose from an imperfect set of disease-specific scales. Second, it has to be decided how best to convert the information from the disease-specific scales into the generic outcome measure. This involves value judgments and, as it was shown in Chapter 4, one's final results may be sensitive to alternative and reasonable categorisations. In addition, there is a risk that in the conversion process, the generic outcome measure may be insensitive to minor changes in clinical conditions. The reason for this is that the two types of measures are designed with different aims and are likely to emphasize different elements of health-related quality of life. Finally, problems may arise when converting information from what are usually ordinal disease-specific scales into cardinal generic scales. It would be advantageous if the disease-specific scales had interval or ratio properties. However, if they have ordinal properties, then transformations from such scales into scales where the differences between points have real meaning, may lead to statistical errors.

### 7.3 Discounting

In Chapter 4, it was shown that the choice of discount rate can affect the relative cost effectiveness of medical procedures. Increases in the discount rate were shown to progressively depreciate the present value of future costs and benefits. When this was combined with a time span factor which also tended to place progressively less weight on costs and benefits accruing in the future, the importance of the selection of a discount rate for health projects was illustrated. It was argued that whichever discount rate a project evaluator chooses, a value judgment is in fact being made on the preference for current over future consumption. Low discount rates extol the virtues of long-lived projects; high discount rates introduce a bias against long-lived projects.

The sensitivity analysis performed on the 5 percent discount rate used by Gudex to calculate the relative cost effectiveness of the seven medical procedures (Chapter 4) produced some interesting results and illustrated the importance of discount rate selection, particularly when two or more projects are being compared. Surgery for idiopathic adolescent scoliosis was particularly affected by the exercise with its Cost per QALY varying 164-fold when the discount rate was varied between 0 percent and 10 percent. This was the result of the long time span over which the benefits of the medical procedure are enjoyed and the one-off costs per case. The sensitivity analysis also had some effect on the relative cost effectiveness of kidney transplantation, shoulder joint replacement surgery and scoliosis surgery for neuromuscular illness. These are all medical procedures for which benefits are enjoyed over a long period of time and for which the costs occur on a one-off basis. The remaining three medical procedures studied by Gudex, CAPD, haemodialysis and ceftazidime treatment of cystic fibrosis, remained unaffected by the exercise, largely because the recurring costs and benefits for these procedures tended to cancel each other out.

In Chapter 3, the discount rate was also shown to affect the final Cost per QALY gained for hip and knee joint replacement surgery. The Cost per QALY gained for the two types of surgery was shown to vary by over £2,000 when discount rates of 0 to 10 percent were applied.

The main issue for discussion which emerges from this section is the appropriate discount rate for inclusion in health care projects. Chapter 4 presented a list of studies, dating from 1958 to 1990, which applied discount rates of between 0 percent and 20 percent. This variation did not seem to be accounted for by the inflation rate prevailing in the economy at the time of the study. In addition, various theories were presented on the correct approach project evaluators should take toward the level of discount rates they apply. The need for discounting future costs remains relatively uncontroversial and the debate in this area tends to revolve around the appropriate rate. However, an interesting debate has emerged recently concerning not only the appropriate rate at which future health effects should be discounted, but also whether future health effects should be discounted at all.

Drummond et al. (1987) present some powerful arguments in favour of discounting future health effects. They argue that failing to discount future health effects, whilst at the same time discounting future costs would lead to inconsistencies, quite impossible conclusions and would ignore the possibilities of trading health through time. Weinstein and Stason (1977) present an example which clarifies these arguments:

"The reason for discounting future life years saved is not that life years can, in any sense, be invested to yield more life years as dollars can be invested to yield more dollars. Nor is it necessary to assume that life years in the future are less valuable than life years today in any absolute utilitarian sense. Rather, the reason for discounting future life years is precisely that they are being valued relative to dollars and, since a dollar in the future is discounted

relative to a present dollar, so must a life year in the future be discounted relative to a present dollar. Consider the following example that illustrates the chain of logic for discounting future health benefits... Suppose that Program A saves one year of life expectancy 40 years hence at a present cost of \$10,000, and that Program B saves one year of life expectancy now at present cost of \$10,000. Which program should have higher priority? To answer this question, consider first a hypothetical Program A<sub>1</sub>, which can save one year of life 40 years hence at a cost of \$70,000 borne in 40 years. This result is equivalent to Program A because \$70,000 in 40 years has a present value (at 5 per cent) of \$10,000 and because the benefits of both programs, A and A<sub>1</sub>, are the same. Now, consider Program A<sub>2</sub>, which simply translates both the benefits and the costs of Program A<sub>1</sub> from the future to the present. Provided life years are valued the same in relation to dollars in the present as in the future, Program A<sub>2</sub> should be considered to have the same long-run priority as Program A<sub>1</sub>. Finally, consider Program A<sub>3</sub>, under which both the benefits and the costs are reduced proportionately in relation to Program A<sub>2</sub> and which, therefore, has the same priority. Now, it is clear that Program B is preferable to Program A<sub>3</sub>, since the costs are identical, but the benefits of Program B, which accrue at the same point in time as those of A<sub>3</sub>, are much more. Moreover, we have seen that Program A<sub>3</sub>, which has the same priority as Program A, could have been derived from Program A simply by discounting the future health benefits. The cost-effectiveness ratio for Program A is thus the present value of cost divided by the present value of benefit, or  $\$10,000 / (1/(1.05)^{40})$ , or \$70,000 per QALY, which compares unfavorably to the \$10,000 per QALY ratio for Program B.

Throughout this argument, it is never stated that, in any absolute sense, a year of life in the future is less valuable than a year of life in the present. It is the discounting of dollar costs, and the assumed constant steady-state relation

between dollars and health benefits, that mandates the discounting of health benefits (i.e., quality-adjusted life years) as well as dollar health costs.

The exact equivalence between  $A_1$  and  $A_2$  that underlies this line of reasoning assumes that opportunities for purchasing health benefits for dollars do not change over time. If it is expected that technology will improve so that it becomes less expensive to save lives,  $A_2$  may be somewhat less valuable than  $A_1$ , suggesting an even higher effective discount rate for life years than for dollar costs. If it is expected that environmental or other factors will conspire to make lifesaving more expensive - that is, more valuable - in the future, a lower discount rate may be in order. Moreover, if it is anticipated that societal attitudes will change so that the willingness to pay for lifesaving increases with time, a lower discount rate may be appropriate.

Another important caveat is that as we move far into the future, the uncertainty about the rate of discount that will obtain at that time increases, as does the uncertainty concerning future uses of health resources that will be available. Hence, the discount rate should be varied over a range of possibilities if the benefits or costs occur in the distant future." (Page 720).

The main argument against discounting future health effects is that it is not clear that people value future health effects any less than their present health. Indeed, concern for fitness and general health, and the willingness of individuals to spend large sums of money on health care, are taken as evidence that human beings are naturally concerned about their future health. Cullis and West (1979) argue that, as a result, a zero discount rate or even a negative rate might be appropriate. This line of thinking has recently found support in the Department of Health which has proposed that a zero discount rate should be applied to future health benefits [Parsonage and Neuburger (1991)].

This writer has no firm opinion about which discount rate should be applied to health care programmes, but believes that the recent debate on the



subject and the results from Chapters 3 and 4 make it imperative that sensitivity analyses are performed on the rates selected to discount future costs and benefits of health care programmes. These sensitivity analyses should preferably include discount rates of 0, 5 and 10 percent. If one's results are shown to be sensitive to alternative discount rates, as Gudex's cost utility estimates and the Cost per QALY estimates for hip and knee replacement surgery in Chapter 3 are, then it should be made clear by the study. This is particularly important when Cost per QALY league tables are presented to health authorities and other bodies with exact cost utility estimates for medical procedures. A failure to perform a sensitivity analysis and to present one's results can be misleading.

#### 7.4 Use of QALY's

The QALY concept is a brave and powerful attempt to tackle the problem of efficiently allocating scarce health care resources. If applied on a comprehensive basis to our own National Health Service (NHS), it would make explicit, choices and priorities which up until recently have been made on a more implicit basis. At present, health care resources in the NHS are allocated by a mixture of formal and informal devices [Stevenson (1991)]. These include the Resource Allocation Working Party (RAWP) formula which divides central government funds between Regional Health Authorities and smaller District Health Authorities, and the rationing of health care through queues and clinical discretion. The advantage of a QALY-based system would be that it would theoretically maximize health output for a given budget and would challenge health professionals to devise a better system. For the first time, health professionals in the NHS would seriously

have to consider the implications of the choices that they have usually taken for granted.

A QALY-based system would work by allocating health care resources according to the relative position of medical procedures on a Cost per QALY league table. Theoretically, once all the data collection problems had been overcome, the most cost effective procedure, at the top of the league table, would be supplied first. The authority or governing body would then proceed to work down the league table and place decreasing priority on the less cost effective procedures, until the health budget is exhausted. Those procedures at the bottom of the league table would fare badly, but would not necessarily be overlooked. Stevenson (1991) argues that the gaps would be filled by private insurance, voluntary agencies and special government funds.

This writer believes that the QALY concept is a useful tool in aiding decision-making in the allocation of scarce health care resources and is certainly the direction that the NHS should be considering. However, it is still very early days for a wholesale application of the approach. A number of issues have been raised by this thesis concerning the QALY approach, which require more detailed discussion and which need to be dealt with before the QALY concept can be comprehensively applied.

As it was shown in Chapter 4, the Cost per QALY league tables which have been constructed have based their results on studies which were performed at different times and in different places. Gudex converted information from the British and overseas medical literature, which covered a 17 year time span (1968-1985), into one league table. This is a methodological error in the sense that the relative costs and consequences of medical procedures should only be compared in this way if the procedures were performed at the same time and in the same location. (In reality, this requirement can never be met and, as a result, no two procedures can strictly be compared). The benefits of medical programmes are likely to improve over time. For example, the study by Boyle

et al. (1976) provides the basis of Gudex's health-related quality of life estimate for antibiotic treatment of cystic fibrosis. However, the period between 1976 and 1986, when Gudex's study was written, saw great improvements in the life expectancy of cystic fibrosis patients [Britton (1989)]. Likewise, the relative costs of alternative medical procedures are likely to vary over time, as a result of technological improvements. Socio-economic factors, such as levels of income, are likely to differ between nations and between regions within nations, implying that the results of studies not performed in the same location may be affected by extraneous factors.

It is also important that the benefit estimates included in Cost per QALY league tables are derived using the same utility measurement technique. As discussed in Chapter 2, different utility methods yield different results. If the QALY concept is to be applied on a wide scale basis, then health economists and health care professionals will have to arrive at some sort of consensus over which measurement technique is the most accurate and most appropriate for the exercise. Even after this problem has been overcome, one can think of other methodological decisions which would have to be made. For example, which costs would be included in the calculations? Would some attempt be made to calculate the costs to relatives and friends of patients?

If Cost per QALY data are to form the basis of resource allocation decisions, then a continuous revision of the data may be necessary. The relative costs and consequences of medical procedures will vary continuously as a result of technological changes. A new programme which appears relatively expensive may improve its cost effectiveness over time, as a result of factors such as economies of scale. Some sort of check in the system may be necessary then to prevent discrimination against new procedures and programmes which are likely to improve their relative cost effectiveness at a later stage of development. This is likely to prove a very difficult task.

Even if all the data collection problems could be overcome, decision makers would still face a number of other problems when they considered the final results. Drummond (1989) suggests that a highly summarized presentation of data is dangerous in that it suggests quick and easy solutions to the decision maker. If this is the case, then decision makers may have to become more involved in the data collection process, so that they can become more aware of the inaccuracy of the final results. In addition, the final Cost per QALY results would reflect averages for each medical procedure, whereas a safer proposition might be to present ranges of Cost per QALY figures for each procedure. A final problem with a Cost per QALY league table would be that it offends against the whole principle of equity within the NHS [Stevenson (1991)]. Even if some safeguards were introduced into the system, the logical outcome would be that some patients whose treatments had high costs per QALY would receive no care at all. Economic efficiency, rather than equity, would be the primary concern of the system and, as a result, it would arguably be safer to keep the present, imperfect, system.

In summary therefore, a wholesale application of the QALY concept to the allocation of scarce health care resources is still a long way off. The data requirements for such a system would be tremendous and a number of methodological problems would have to be overcome. Even if these problems could be tackled, a system based on the QALY concept might require decision makers to implement unpopular policies in the name of economic efficiency. Certainly, choices will sooner or later have to be made more explicit, but it seems that a good starting point would be to consider the QALY approach within clinical fields, as suggested by Donaldson et al. (1988). A number of lessons could be learnt from such a process which would help prevent future problems.

## 7.5 Collections of Original Data

Chapters 4 to 6 were constructive in that they taught us a number of lessons about using existing data sets as a basis for resource allocation decisions. It was shown that converting existing medical information into generic health status indices is an informative indicator of the benefits of health programmes. However, we learnt that care should be taken to ensure that such medical information has been derived from representative patient cohorts and, that in the conversion process, realistic categorisations are made. In addition, it was learnt that, where time constraints or lack of resources deem it necessary to estimate the benefits of health programmes without any hard data, specialist clinical advice should be sought. The importance of performing sensitivity analyses on all assumptions was discussed. In terms of the costs of health programmes, it was argued that researchers should reveal the cost components incorporated into their estimates and their methods of calculation.

Despite the lessons that can be learnt from working with existing medical information, an important conclusion of this thesis must surely be that the collection of original data is the most reliable method on which to base resource allocation decisions. Collecting original data allows decision makers to design studies which avoid many of the problems discussed in Chapters 4 to 6, such as conversions into generic health status indices. It is particularly important that an attempt should be made to collect original data when the health-related quality of life of patients is an important outcome, and when the existing environment only permits the collection of intermediate output effectiveness data.

Despite time constraints, resource constraints and the perceived suspicion on the part of health professionals, it is still difficult to understand the paucity of studies which have collected original health state utility values. The

experience of this writer was that, after an initial fear of being intimidated by the whole process had been overcome, the vast majority of health professionals and patients were keen to cooperate in the joint replacement study (Chapter 3), and indeed were very interested in the project. It seems that this was the first attempt to measure the health-related quality of life of joint replacement patients at the Dundee Royal Infirmary. An initial fear of being treated with suspicion did not materialise. Rather, after they had learnt what the aims of the study were, the consultants and nurses took an increasing interest in its progress over the nine month period of interviews. The consultants, in particular, were interested in the results of the study. One commented that he was surprised that the health-related quality of life of patients who had knee replacement surgery improved after the three month period and, after hearing the result, later found that it was confirmed by his own experience with patients who had returned for their reviews.

This experience with health professionals leads to two suggestions. First, there should be more two-way interaction and communication between social scientists and health professionals. Neither group should fear the other. Rather, both have a great deal to learn from each other. Health professionals appreciate the resource constraints facing the National Health Service, and would prefer to play a more important role in the decision-making process. Social scientists should not fear working with either health professionals or patients. Second, if health state utilities are to be measured on a widescale basis, then there is no reason why the health professionals themselves should not play a greater role in the measurement process. It was shown in Chapter 3 that the Rosser-Kind Classification of Illness States is a reliable measure of the health-related quality of life of patients who have undergone joint replacement surgery. It would take health professionals very little extra time to apply such a generic health status index to each of their patients. This would avoid employing outsiders to undertake the task. Of course, a number

of problems would still have to be overcome, such as ensuring that the patients are representative of their illness groups, but there is no reason why health professionals should not be given a greater role in the health status measurement and decision making processes.

### 7.6 Lessons to be Learnt

To sum up then, a number of issues have been raised by this thesis which need more thorough consideration by academics, policy analysts and decision makers.

First, in selecting a health status measurement technique to be incorporated into an economic evaluation of health care programmes, one should try to use one of the health measurement instruments (the rating scale, the standard gamble approach, the time trade-off approach, ratio scaling and the equivalence method) or one of the cardinal-scaled health status indices (e.g. Rosser-Kind Classification of Illness States). These provide relatively accurate approaches to the quantitative valuation of health status and avoid some of the more difficult value judgments which are incorporated into the other techniques.

Second, whichever measurement instrument is chosen to obtain utility and ultimately QALY values, the number and combination of subjects whose preferences form the basis of the valuations should be stated explicitly. A discussion should follow explaining why it is believed that these subjects are representative. In addition, the questionnaire or interview approach selected should also be defended.

Third, developing Cost per QALY league tables which compare the results of different studies can be misleading and can contain a number of methodological errors. A consensus should be reached concerning the most accurate and most appropriate measurement technique to be included in such studies, and an attempt should be made to avoid timing, location and development stage discrepancies. This is likely to prove a very difficult task. In the meantime, health economists can begin the process by comparing Cost per QALY results within clinical fields.

Fourth, the Rosser-Kind Classification of Illness States is an accurate health status measurement technique. However, if it is to become more widely used to compare the health-related quality of life of patient undergoing alternative medical treatments, then it should at least be borne in mind that it may be insensitive in picking up minor fluctuations in the health-related quality of life of certain groups of patients. The best solution would be to develop a new health status index which overcomes this insensitivity problem, but still allows across-programme comparisons to be made.

Fifth, prospective data would be preferable in assessing the health-related quality of life of groups of patients. Ideally, follow-up studies should be performed to measure the health-related quality of life of patients at later stages in life. If retrospective data have to be used, then tests will have to be incorporated into the studies to check for any biases in the final results.

Sixth, all assumptions of a study should be made explicit at the outset. It should be obvious to the reader which measurement technique was selected, how the study was conducted and all analogous assumptions. In particular, evidence should be provided to support the assumption of health-related quality of life improvement following medical treatment.



Seventh, whatever the chosen health status measurement technique, when estimating the QALY's gained for each medical procedure, reasonable assumptions concerning the survival period / life expectancy of each patient, conversions into health status indices and the discount rate should be tested using sensitivity analyses. If the final results are shown to be sensitive to such analyses, then it might be safer to present them in terms of ranges, rather than exact figures.

Eighth, studies which present medical information (such as the placebo controlled antibiotic trials encountered in Chapter 5) should present all relevant data (pretreatment and posttreatment scores) for each parameter evaluated. This would make comparative studies more straightforward.

Ninth, prognostic scores which are used as sources of information for each medical condition, should provide comprehensive measures of health-related quality of life. They should avoid assuming that all elements are independent of each other, and should avoid turning continuous variables into discrete variables. In addition, the information they provide should easily be convertible into more generic health status indices.

Tenth, all studies should clarify which costs and benefits were included in their estimates. If the list of cost and benefit components is less than comprehensive, then authors should make some sort of estimate of the likely effects of a more comprehensive list.

Eleventh, there should be more interaction and cooperation between social scientists and health professionals in the health status measurement process.

It is hoped that these ideas can help improve health status measurement approaches and their inclusion in economic evaluations. Their incorporation would be a great step forward for one of the most difficult problems in health economics, namely the valuation of health outcome.

## REFERENCES

- Acton, J.P. (1973). *Evaluating public programs to save lives. The case of heart attacks*. Rand Corporation, R-73-02, Santa Monica, California, USA.
- Adar, R. and Pliskin, N. (1980). Cost analysis of the utilization of new vascular grafts. *Metamedicine* 1, 213-223.
- Anbar, R.D., Lapey, A., Khaw, K.T., Spragg, J., Strieder, D.J., Shaw, L.F., Kelly, D.H., and Shannon, D.C. (1990). Does lithium carbonate affect the ion transport abnormality in cystic fibrosis? *Pediatric Pulmonology* 8, 82-88.
- Andersen, B. (1990). *Methodological errors in medical research*. Blackwell Scientific Publications, Oxford.
- Barnum, H. (1987). Evaluating healthy days of life gained from health projects. *Social Science and Medicine* 24, 833-841.
- Batten, J.C. (1983). The adolescent and adult. In *Cystic fibrosis* (eds M.E. Hodson, A.P. Norman and J.C. Batten), pp. 209-218. London.
- Beaudry, P.H., Marks, M.I., McDougall, D., Desmond, K., and Rangel, R. (1980). Is anti-Pseudomonas therapy warranted in acute respiratory exacerbations in children with cystic fibrosis? *Journal of Pediatrics* 97 (1), 144-147.
- Bergner, M., Bobbitt, R.A., Kressel, S., Pollard, W.E., Gilson, B.S., and Morris, J.R. (1976). The Sickness Impact Profile: conceptual formulation and methodology for the development of a health status measure. *International Journal of Health Services* 6, 393-415.
- Berwick, D.M., Cretin, S., and Keeler, E. (1981). Cholesterol, children, and heart disease: an analysis of alternatives. *Pediatrics* 68, 721-730.
- Berwick, D.M. and Komaroff, M.D. (1982). Cost-effectiveness of lead screening. *New England Journal of Medicine* 306, 1392-1398.
- Beyt, B.E., Troxler, S., and Cavaness, J. (1985). Prospective payment and infection control. *Infection Control* 4, 161-164.
- Bland, J.M. and Altman, D.G. (February 8, 1986). Statistical Methods for assessing agreement between two methods of clinical measurement. *Lancet*, 307-310.
- Bonney, S., Finkelstein, F.O., Lytton, B., Schiff, M., and Steele, T.E. (1978). Treatment of end-stage renal failure in a defined geographic area. *Archives of Internal Medicine* 138, 1510-1513.

- Bowman, R.R., Guyer, W.D., and Bos, G.D. (1991). Total knee arthroplasty at a veterans administration medical center. *Clinical Orthopaedics and Related Research* 269, 51-57.
- Boyle, I.R., Di Sant'Agnese, P.A., Sacks, S., Millican, F., and Kulczycki, L.L. (1976). Emotional adjustment of adolescents and young adults with cystic fibrosis. *Journal of Paediatrics* 88 (2), 318-326.
- Boyle, M.H., Torrance, G.W., Sinclair, J.C., and Horwood, S.P. (1983). Economic evaluation of neonatal intensive care of very-low-birth-weight infants. *New England Journal of Medicine* 308 (22), 1330-1337.
- Breslow, L. (1972). A quantitative approach to the world health organization definition of health: physical, mental and social well-being. *International Journal of Epidemiology* 1, 347-355.
- Breyer, F. and Fuchs, V.R. (1982). *Risk attitudes in health: an exploratory study*. NBER Working Paper No.875, Cambridge, M.A.
- Britton, J.R. (1989). Effects of social class, sex, and region of residence on age at death from cystic fibrosis. *British Medical Journal* 298, 483-487.
- Bulpitt, C.J. and Fletcher, A.E. (1990). The measurement of quality of life in hypertensive patients: a practical approach. *Br J Clin Pharmacol* 30, 353-364.
- Bush, J.W., Chen, M.M., and Patrick, D.L. (1973). Health status index in cost-effectiveness: analysis of PKU programme. In *Health status indexes* (ed. R.L. Berg), pp 172-194. Hospital Research and Educational Trust, Chicago.
- Buxton, M., Ashby, J., and O'Hanlon, M. (1986). *Valuation of health states using the time trade-off approach: report of a pilot study relating to health states one year after treatment for breast cancer*. HERG Discussion Paper No.2., Brunel University.
- Bywater, E.M. (1981). Adolescents with cystic fibrosis: psychosocial adjustment. *Archives of Disease in Childhood* 56, 538-543.
- Carswell, F., Ward, C., Cook, D.A., and Speller, D.C.E. (1987). A controlled trial of nebulized aminoglycoside and oral flucloxacillin versus placebo in the outpatient management of children with cystic fibrosis. *Br J Dis Chest* 81, 356-360.
- Chaput de Saintonge, D.M., Kirwan, J.R., Evans, S.J.W., and Crane, G.J. (1988). How can we design trials to detect clinically important changes in disease severity? *Br J Clin Pharmacol* 26, 355-362.
- Clayton, M.L., Ferlic, D.C., and Jeffers, P.D. (1982). Prosthetic arthroplasties of the shoulder. *Clinical Orthopaedics and Related Research* 164, 184-191.

- Cofield, R.H. (1984). Total shoulder arthroplasty with the Neer prosthesis. *Journal of Bone and Joint Surgery* 66-A (6), 899-906.
- Cohen, L.F., di Sant'Agnes, P.A., and Friedlander, J. (1980). Cystic fibrosis and pregnancy: A national survey. *Lancet* 2, 842-844.
- Collis, D.K. and Ponseti, I.V. (1969). Long-term follow-up of patients with idiopathic scoliosis not treated surgically. *Journal of Bone and Joint Surgery* 51-A (3), 425-445.
- Conway, S.P., Miller, M.G., Ramsden, C., and Littlewood, J.M. (1985). Intensive treatment of pseudomonas chest infection in cystic fibrosis: a comparison of tobramycin and ticarcillin, and netilmicin and ticarcillin. *Acta Paediatr Scand* 74, 107-113.
- Cullis, J.G. and West, P.A. (1979). *The economics of health: an introduction*. Martin Robertson.
- Culyer, A.J. (1978). *Measuring health: lessons for Ontario*. Ontario Economic Council, Toronto, Canada.
- Culyer, A.J. and Maynard, A.K. (1981). Cost-effectiveness of duodenal ulcer treatment. *Social Science and Medicine* 15C, 3-11.
- Dasgupta, A.K. and Pearce, D.W. (1978). *Cost-benefit analysis: theory and practice*. Macmillan Student Editions.
- Davey, P., Dodd, T., Kerr, S., and Malek, M. (1990). Audit of IV antibiotic administration. *Pharmaceutical Journal*, 793-796.
- David, T.J. (1989). Intravenous antibiotics at home in children with cystic fibrosis. *Journal of the Royal Society of Medicine* 82, 8-9.
- David, T.J., Phillips, B.M., and Connor, P.J. (1983). Ceftazidime - a significant advance in the treatment of cystic fibrosis. *Journal of Antimicrobial Chemotherapy* 12 (Suppl A), 337-340.
- Davies, T.W. and Cottingham, J. (1979). The cost of hospital infection in orthopaedic patients. *Journal of Infection* 1 (4), 329-338.
- Denning, C.R., Park, S., Grece, C.A., and Gilbert, W.M. (1977). Continuous vs intermittent oral antibiotics in the management of patients with cystic fibrosis. *Cystic Fibrosis Club Abstract*, 13.
- Dickson, R.A. (1983). Scoliosis in the community. *British Medical Journal* 286, 615-618.
- Dixon, R.E. (1978). Effect of infections on hospital care. *Annals of Internal Medicine* 89 (2), 749-753.

- Dixon, R.E. (1985). Economic costs of respiratory infections in the United States. *American Journal of Medicine* 78 (6B), 45-51.
- Donaldson, C., Atkinson, A., Bond, J., and Wright, K. (1988). Should QALYS be programme-specific? *Journal of Health Economics* 7, 239-257.
- Donati, M.A., Guenette, G., and Auerbach, H. (1987). Prospective controlled study of home and hospital therapy of cystic fibrosis pulmonary disease. *Journal of Pediatrics* 111 (1), 28-33.
- Drummond, M.F. (1981). Welfare economics and cost-benefit analysis in health care. *Scottish Journal of Political Economy* 28 (2), 125-145.
- Drummond, M.F. (1989). Output measurement for resource allocation decisions in health care. *Oxford Review of Economic Policy* 5 (1), 59-74.
- Drummond, M.F., Ludbrook, A., Lowson, K.V., and Steele, A. (1986). *Studies in economic appraisal in health care*, Vol.2. Oxford University Press.
- Drummond, M.F., Stoddart, G.L., and Torrance, G.W. (1987). *Methods for the economic evaluation of health care programmes*. Oxford University Press.
- Edwards, W. (1977). How to use multiattribute utility measurement for social decision making. *IEEE Transactions on Systems, Man and Cybernetics* 7, 326-340.
- Elstein, A.S., Holzman, G.B., Ravitch, M.M., Metheny, W.A., Holmes, M.M., Hoppe, R.B., Rothert, M.L., and Rovner, D.R. (1986). Comparison of physicians decisions regarding estrogen replacement therapy for menopausal women and decisions derived from a decision analytic model. *The American Journal of Medicine* 80., 246-258.
- Enke, S. (1966). The economic aspects of slowing population growth. *Economic Journal* 76, 44-56.
- Eraker, S.A. and Sox, H.C. (1981). Assessment of patients preferences for therapeutic outcomes. *Medical Decision Making* 1 (1), 29-39.
- Euroqol Group. (1990). Euroqol - a new facility for the measurement of health-related quality of life. *Health Policy* 16 (3), 199-208.
- Evans, R.W., Hart, L.G., and Manninen, D.L. (1984). A comparative assessment of the quality of life of successful kidney transplant patients according to source of graft. *Transplantation Proceedings* 16 (5), 1353-1358.
- Evans, R.W., Manninen, D.L., Garrison, L.P., Hart, L.G., Blagg, C.R., Gutman, R.A., Hull, A.R., and Lowrie, E.G. (1985). The quality of life of patients with end-stage renal disease. *New England Journal of Medicine* 312 (9), 553-559.

- Fein, R. (1958). *Economics of mental illness*. Basic Books, New York.
- Fein, R. (1977). But on the other hand: high blood pressure, economics and equity. *New England Journal of Medicine* 296 (13), 751-753.
- Gafni, A. and Torrance, G. (1984). Risk attitudes and time preferences in health. *Management Science* 30 (4), 440-451.
- Geddes, D.M. (1988). Antimicrobial therapy against staphylococcus aureus, Pseudomonas aeruginosa, and pseudomonas cepacia. *Chest* 94 (2), 140S-144S.
- Gilbert, J., Robinson, T., and Littlewood, J.M. (1988). Home intravenous antibiotic treatment in cystic fibrosis. *Archives of Disease in Childhood* 63, 512-517.
- Girard, R., Fabry, J., Meynet, R., Lambert, D.C., and Sepetjan, M. (1983). Costs of nosocomial infection in a neonatal unit. *Journal of Hospital Infection* 4 (iv), 361-366.
- Gold, R. (1987). Mild to moderate chest exacerbations: do antibiotics help? *Pediatr Pulmonology* 1 (Suppl 1), 38-39.
- Gold, R., Carpenter, S., Heurter, H., Corey, M., and Levison, H. (1987). Randomized trial of ceftazidime versus placebo in the management of acute respiratory exacerbations in patients with cystic fibrosis. *Journal of Pediatrics* 111 (6), 907-913.
- Gold, R., Overmeyer, A., Knie, B., Fleming, P.C., and Levison, H. (1985). Controlled trial of ceftazidime vs. ticarcillin and tobramycin in the treatment of acute respiratory exacerbations in patients with cystic fibrosis. *Pediatric Infectious Disease* 4 (2), 172-177.
- Goldstein, H. and Philip, J. (1990). A cost-benefit analysis of prenatal diagnosis by amniocentesis in Denmark. *Clin Genet* 37, 241-263.
- Green, J.W. and Wenzel, R.P. (1977). Postoperative wound infection : a controlled study of the increased duration of hospital stay and direct cost of hospitalization. *Annals of Surgery* 185, 264-268.
- Grogono, A.W. and Woodgate, D.J. (1971). Index for measuring health. *Lancet* 2, 1024-1026.
- Gudex, C. (1986). *QALY's and their use by the health service*. University Of York, Centre For Health Economics, Discussion Paper 20.
- Haley, R.W., Schaberg, D.R., Crossley, K.B., Von Allmen, S.D., and McGowan, J.E. (1981). Extra charges and prolongation of stay attributable to nosocomial infections : a prospective interhospital comparison. *American Journal of Medicine* 70, 51-58.

- Harris, A.I., Cox, E., and Smith, C.R.W. (1971). *Handicapped and impaired in Great Britain*. HMSO, London.
- Hartunian, N.S., Smart, C.N., and Thompson, M.S. (1980). The incidence and economic costs of cancer, motor vehicle injuries, coronary heart disease and stroke: a comparative analysis. *American Journal of Public Health* 70, 1249-1260.
- Henderson, J.B. (1982). An economic appraisal of the benefits of screening for open spina bifida. *Social Science and Medicine* 16, 545-560.
- Henley, L.D. and Hill, I.D. (1990). Global and specific disease-related information needs of cystic fibrosis patients and their families. *Pediatrics* 85 (6), 1015-1021.
- Hodson, M.E. (1988). Antibiotic treatment: aerosol therapy. *Chest* 94 (2), 156S-160S.
- Hodson, M.E., Penketh, A.R.L., and Batten, J.C. (1981). Aerosol carbenicillin and gentamicin treatment of *Pseudomonas aeruginosa* infection in patients with cystic fibrosis. *Lancet* 1, 1137-1139.
- Hoiby, N. and Koch, C. (1990). *Pseudomonas aeruginosa* infection in cystic fibrosis and its management. *Thorax* 45, 881-884.
- Hunt, S.M., McEwen, J., and McKenna, S.P. (1985). Measuring health status: a new tool for clinicians and epidemiologists. *Journal of the Royal College of General Practitioners* 35, 185-188.
- Hutchinson, T.A., Boyd, N.F., Feinstein, A.R., Gonda, A., Hollomby, D., and Rowat, B. (1979). Scientific problems in clinical scales, as demonstrated in the Karnofsky Index of Performance Status. *Journal Of Chronic Diseases* 32, 661-666.
- Hyatt, A.C., Chipps, B.E., Kumor, K.M., Mellits, E.D., Lietman, P.S., and Rosenstein, B.J. (1981). A double-blind controlled trial of anti-*Pseudomonas* chemotherapy of acute respiratory exacerbations in patients with cystic fibrosis. *Journal of Pediatrics* 99 (2), 307-311.
- Inman, R.P. (1987). The economic consequences of debilitating illness: the case of multiple sclerosis. *Review of Economics and Statistics* 69, 651-660.
- Irvin, G. (1978). *Modern cost-benefit methods. An introduction to financial, economic and social appraisal of development projects*. Macmillan Press, London.
- Izsak, F.C. and Medalie, J.H. (1971). Comprehensive follow-up of carcinoma patients. *Journal Of Chronic Diseases* 24, 179-191.



Jensen, T., Pederson, S.S., Garne, S., Heilmann, C., Hoiby, N., and Koch, C. (1987). Colistin inhalation therapy in cystic fibrosis patients with chronic *Pseudomonas aeruginosa* lung infection. *Journal of Antimicrobial Chemotherapy* 19, 831-838.

Jensen, T., Pederson, S.S., Hoiby, N., Koch, C., and Flensburg, E.W. (1989). Use of antibiotics in cystic fibrosis: the Danish approach. In *Pseudomonas aeruginosa infection. Antibiot Chemother* (eds N. Hoiby, S.S. Pederson, G.H. Shand, G. Doring and I.A. Holder) Vol.42, pp. 237-246. Basel, Karger.

Kahneman, D. and Tversky, A. (1979). Prospect theory: an analysis of decision under risk. *Econometrica* 47 (2), 263-291.

Kannel, W.B. and Gordon, T. (1970). *The Framingham Study: an epidemiological investigation of cardiovascular disease. Sect 26.* Government Printing Office, Washington, D.C.

Kaplan, R.M. and Bush, J.W. (1982). Health-related quality of life measurement for evaluation research and policy analysis. *Health Psychology* 1 (1), 61-80.

Kaplan, R.M., Bush, J.W., and Berry, C.C. (1976). Health status. Types of validity and the index of well-being. *Health Services Research* 11 (4), 478-507.

Kaplan, R.M., Bush, J.W., and Berry, C.C. (1979). Health status index. Category rating versus magnitude estimation for measuring levels of well-being. *Medical Care* 17 (5), 501-525.

Karnofsky, D.A., Abelmann, W.H., Craver, L.F., and Burchenal, J.H. (1948). The use of the nitrogen mustards in the palliative treatment of carcinoma, with particular reference to bronchogenic carcinoma. *Cancer*, 634-656.

Karnofsky, D.A. and Burchenal, J.H. (1949). The clinical evaluation of chemotherapeutic agents in cancer. In *Evaluation of chemotherapeutic agents* (ed C.M. Macleod), pp 191-205. Columbia University Press, New York.

Kattan, M., Mansell, A., Levison, H., Corey, M., and Krastins, I.R.B. (1980). Response to aerosol salbutamol, SCH 1000, and placebo in cystic fibrosis. *Thorax* 35, 531-535.

Katz, S. (1987). The Portugal Conference: measuring quality of life and functional status in clinical and epidemiological research. *Journal of Chronic Diseases: Forum For Clinical Epidemiology*.

Katz, S. and Akpom, C.A. (1976). A measure of primary sociobiological functions. *International Journal of Health Services* 6, 493-507.

Keeler, E.B., Manning, W.G., Newhouse, J.P., Sloss, E.M., and Wasserman, J. (1989). The external costs of a sedentary life-style. *American Journal of Public Health* 79, 975-981.

Keeney, R.L. and Raiffa, H. (1976). *Decisions with multiple objectives. Preferences and value tradeoffs*. Wiley Publications, New York.

Kerem, E., Corey, M., Gold, R., and Levison, H. (1990). Pulmonary function and clinical course in patients with cystic fibrosis after pulmonary colonization with *Pseudomonas aeruginosa*. *Journal of Pediatrics* 116 (5), 714-719.

Kilgus, D.J., Dorey, F.J., Finerman, G.A.M., and Amstutz, H.C. (1991). Patient activity, sports participation, and impact loading on the durability of cemented total hip replacements. *Clinical Orthopaedics and Related Research* 269, 25-31.

Kind, P., Rosser, R., and Williams, A. (1982). Valuation of quality of life: some psychometric evidence. In *The value of life and safety* (ed M.W. Jones-Lee), pp 159-170. Amsterdam: Elsevier/North Holland.

Klarman, H.E. (1965). Syphilis control programs. In *Measuring benefits of government investment* (ed. R. Dorfman), pp. 367-414. Brookings Institute, Washington DC.

Klarman, H.E. (1982). The road to cost-effectiveness analysis. *Milbank Memorial Fund Quarterly* 60 (4), 585-603.

Kriedel, T. (1980). Cost-benefit analysis of epilepsy clinics. *Social Science and Medicine* 14C, 35-39.

Krilov, L.R., Blumer, J.L., Stern, R.C., Hartstein, A.I., Iglewski, B.N., and Goldmann, D.A. (1985). Imipenem/Cilastatin in acute pulmonary exacerbations of cystic fibrosis. *Reviews of Infectious Diseases* 7 (3), 482-489.

Kun, P., Landau, L.I., and Phelan, P.D. (1984). Nebulized gentamicin in children and adolescents with cystic fibrosis. *Aust Paediatr J* 20, 43-45.

Kuzemko, J.A. (1988). Home treatment of pulmonary infections in cystic fibrosis. *Chest* 94 (2), 162S-165S.

Kuzemko, J.A. and Williams, K.J. (1986). Home intravenous treatment of pulmonary infections in cystic fibrosis. In *Cystic fibrosis in children: practical and legal aspects of intravenous antibiotic administration in the home* (ed. T.J. David), pp 29-32. Excerpta Medica, Amsterdam.

Labelle, R.J., Churchill, D.N., Martin, S., Isbister, E., and Orovan, W. (1987). Economic evaluation of extracorporeal shock wave lithotripsy, percutaneous ultrasonic lithotripsy, and standard surgical treatment of urolithiasis - a Canadian perspective. *Clin Invest Med* 10, 86-95.

Larsen, G.L., Barron, R.J., Landay, R.A., Cotton, E.K., Gonzales, M.A., and Brooks, J.G. (1980). Intravenous aminophylline in patients with cystic fibrosis. *Am J Dis Child* 134, 1143-1148.

Levin, H.M. (1975). Cost-effectiveness analysis in evaluation research. In *Handbook of evaluation research* (eds M. Guttentag and E.L. Struening) Vol. 2, pp 89-122. Sage Publications, London.

Levy, J., Smith, A.L., Koup, J.R., Williams-Warren, J., and Ramsey, B. (1984). Disposition of tobramycin in patients with cystic fibrosis: A prospective controlled study. *Journal of Pediatrics* 105 (1), 117-123.

Loening-Baucke, V.A., Mischler, E., and Myers, M.G. (1979). A placebo-controlled trial of cephalexin therapy in the ambulatory management of patients with cystic fibrosis. *Journal of Pediatrics* 95 (4), 630-637.

Lowson, K.V., Drummond, M.F., and Bishop, J.M. (1981). Costing new services: long-term domiciliary oxygen therapy. *Lancet* i, 1146-1149.

Ludbrook, A. (1981). A cost-effectiveness analysis of the treatment of chronic renal failure. *Applied Economics* 13, 337-350.

McLaughlin, F.J., Matthews, W.J., Strieder, D.J., Sullivan, B., Taneja, A., Murphy, P., and Goldmann, D.A. (1983). Clinical and bacteriological responses to three antibiotic regimens for acute exacerbations of cystic fibrosis: ticarcillin-tobramycin, azlocillin-tobramycin, and azlocillin-placebo. *Journal of Infectious Diseases* 147 (3), 559-567.

McNeil, B.J., Pauker, S.G., Sox, H.C., and Tversky, A. (1982). On the elicitation of preferences for alternative therapies. *New England Journal of Medicine* 306 (21), 1259-1262.

McNeil, B.J., Weichselbaum, R., and Pauker, S.G. (1978). Fallacy of the five-year survival in lung cancer. *New England Journal of Medicine* 299 (25), 1397-1401.

McNeil, B.J., Weichselbaum, R., and Pauker, S.G. (1981). Tradeoffs between quality and quantity of life in laryngeal cancer. *New England Journal of Medicine* 305 (17), 982-987.

Mantle, D.J. and Norman, A.P. (1966). Life-table for cystic fibrosis. *British Medical Journal* 2, 1238-1241.

- Martin, A.J., Smalley, C.A., George, R.H., Healing, D.E., and Anderson, C.M. (1980). Gentamicin and tobramycin compared in the treatment of mucoid *Pseudomonas* lung infections in cystic fibrosis. *Archives of Disease in Childhood* 55, 604-607.
- Mooney, G.H. (1986). *Economics, medicine and health care*. Harvester Press.
- Mooney, G.H., Russell, E.M., and Weir, R.D. (1980). *Choices for health care*. Macmillan Press, London.
- Mouton, J.W. and Kerrebijn, K.F. (1990). Antibacterial therapy in cystic fibrosis. *Medical Clinics of North America* 74 (3), 837-850.
- Muller, A. and Reutzel, T.J. (1984). Willingness to pay for reduction in fatality risk: an exploratory survey. *American Journal of Public Health* 74 (8), 808-812.
- Neer, C.S., Watson, K.C., and Stanton, F.J. (1982). Recent experience in total shoulder replacement. *Journal of Bone and Joint Surgery* 64-A (3), 319-337.
- Nelson, J.D. (1985). Management of acute pulmonary exacerbations in cystic fibrosis: A critical appraisal. *Journal of Pediatrics* 106 (6), 1030-1033.
- Nilsonne, U. and Lundgren, K.D. (1968). Long-term prognosis in idiopathic scoliosis. *Acta Orthopaedica Scandinavica* 39, 456-465.
- Nissinen, A., Tuomilehto, J., Kottke, T.E., and Puska, P. (1986). Cost-effectiveness of the North Karelia hypertension program. 1972-1977. *Medical Care* 24, 767-780.
- Orenstein, D.M., Nixon, P.A., Ross, E.A., and Kaplan, R.M. (1989). The quality of well-being in cystic fibrosis. *Chest* 95 (2), 344-347.
- Ostrowsky, J.T., Lippman, A., and Scriver, C.R. (1985). Cost-benefit analysis of a thalassemia disease prevention program. *American Journal of Public Health* 75, 732-736.
- Pan, S.H., Canafax, D.M., Le, C.T., Cipolle, R.J., Uden, D.L., and Warwick, W.J. (1989). Bronchodilation from intravenous theophylline in patients with cystic fibrosis: Results of a blinded placebo-controlled crossover clinical trial. *Pediatric Pulmonology* 6, 172-179.
- Park, S., Grece, C.A., and Denning, C.R. (1977). Continuous use of oral antibiotics in the management of patients with cystic fibrosis. *Am Rev Resp Dis* 115 (Suppl), 288.
- Parry, M.F., Neu, H.C., Merlino, M., Gaerlan, P.F., Ores, C.N., and Denning, C.R. (1977). Treatment of pulmonary infections in patients with cystic fibrosis: a comparative study of ticarcillin and gentamicin. *Journal of Pediatrics* 90, 144-148.

- Parsonage, M. and Neuburger, H. (1991). *Discounting and QALY's*. Paper presented at Aberdeen Health Economics Study Group.
- Patrick, D.L., Bush, J.W., and Chen, M.M. (1973). Toward an operational definition of health. *Journal of Health and Social Behaviour* 14, 6-23.
- Pauker, S.G. (1976). Coronary artery surgery: the use of decision analysis. *Annals of Internal Medicine* 85, 8-18.
- Pauker, S.G. and McNeil, B.J. (1981). Impact of patient preferences on the selection of therapy. *Journal of Chronic Disability* 34, 77-86.
- Pauker, S.P. and Pauker, S.G. (1977). Prenatal diagnosis: a directive approach to genetic counselling using decision analysis. *Yale Journal of Biology and Medicine* 50, 275-289.
- Pederson, S.S., Jensen, T., Hoiby, N., Kocch, C., and Flensburg, E.W. (1987). Management of *Pseudomonas aeruginosa* lung infection in Danish cystic fibrosis patients. *Acta Paediatr Scand* 76, 955-961.
- Penketh, A.R.L., Hodson, M.E., and Batten, J.C. (1982). Long-term use of aerosol antibiotics in adults with cystic fibrosis. In *Proceedings of the 11th Annual Meeting of the European Working Group in Cystic Fibrosis, Brussels, Belgium*. Belgian Cystic Fibrosis Association, Brussels.
- Permin, H., Koch, C., Hoiby, N., Christensen, H.O., Moller, A.F., and Moller, S. (1983). Ceftazidime treatment of chronic *Pseudomonas aeruginosa* respiratory tract infection in cystic fibrosis. *Journal of Antimicrobial Chemotherapy* 12 (Suppl A), 313-323.
- Pinner, R.W., Haley, R.W., Blumenstein, B.A., Schaberg, D.R., Von Allmen, S.D., and McGowan, J.E. (1982). High cost nosocomial infections. *Infection Control* 3 (2), 143-149.
- Pliskin, J.S., Shepard, D.S., and Weinstein, M.C. (1980). Utility functions for life years and health status. *Operations Research* 28, 206-224.
- Pliskin, J.S., Stason, W.B., Weinstein, M.C., Johnson, R.A., Cohn, P.F., McEnany, M.T., and Braun, P. (1981). Coronary artery bypass graft surgery. Clinical decision making and cost-effectiveness analysis. *Medical Decision Making* 1 (1), 10-28.
- Pole, D. (1971). Mass radiography: a cost-benefit approach. In *Problems and progress in medical care* (ed. G. McLachlan). University Press, Oxford.
- Ponnighaus, J.M. (1980). The cost/benefit of measles immunization: a study from Southern Zambia. *Journal of Tropical Medicine and Hygiene* 83, 141-149.

Prince, A.S. and Neu, H.C. (1980). Use of piperacillin, a semisynthetic penicillin, in the therapy of acute exacerbations of pulmonary disease in patients with cystic fibrosis. *Journal of Pediatrics* 97, 148.

Procci, W.R. (1980). A comparison of psychosocial disability in males undergoing maintenance haemodialysis or following cadaver transplantation. *General Hospital Psychiatry* 2, 255-261.

Raiffa, H. (1969). *Preferences for multiattributed alternatives*. Rand Corporation, RM-5868-DOT/RC, Santa Monica, California, USA.

Read, J.L., Quinn, R.J., Berwick, D.M., Fineberg, H.V., and Weinstein, M.C. (1984). Preferences for health outcomes: comparison of assessment methods. *Medical Decision Making* 4 (3), 315-329.

Regelmann, W.E., Elliott, G.R., Warwick, W.J., and Clawson, C.C. (1990). Reduction of sputum *Pseudomonas aeruginosa* density by antibiotics improves lung function in cystic fibrosis more than do bronchodilators and chest physiotherapy alone. *Am Rev Respir Dis* 141, 914-921.

Roberts, S.D., Maxwell, D.R., and Gross, T.L. (1980). Cost-effective care of end-stage renal disease: a billion dollar question. *Annals of Internal Medicine* 92, 243-248.

Robinson, P. and Sly, P.D. (1990). Placebo-controlled trial of misoprostol in cystic fibrosis. *Journal of Pediatric Gastroenterology and Nutrition* 11 (1), 37-40.

Rose, R., Hunting, K.J., Townsend, T.R., and Wenzel, R.P. (1977). Morbidity/Mortality and economics of hospital-acquired blood stream infections : a controlled study. *Southern Medical Journal* 70, 1267-1269.

Rosser, R.M. and Kind, P. (1978). A scale of valuations of states of illness: is there a social consensus? *International Journal of Epidemiology* 7 (4), 347-358.

Rosser, R.M. and Watts, V. (1975). A clinical classification of disability and distress and its application to the awards made by the courts in personal injury cases. *New Law Journal* 125, 323-328.

Ruchlin, H.S., Finkel, M.L., and McCarthy, E.G. (1982). The efficacy of second-opinion consultation programs: a cost-benefit perspective. *Medical Care* 20: 3-20.

Ruesch, J., Jospe, S., Peterson, H.W., and Imbeau, S. (1972). Measurement of social disability. *Comprehensive Psychiatry* 13, 507-518.

Rundell, O., Jones, R.K., and Gregory, D. (1981). Practical benefit-cost analysis for alcoholism programmes. *Alcoholism: Clinical and Experimental Research* 5, 497-509.

Sackett, D.L., Chambers, L.W., Macpherson, A.S., Goldsmith, C.H., and McAuley, R.G. (1977). The development and application of indices of health: general methods and a summary of results. *American Journal of Public Health* 67, 423-428.

Sackett, D.L. and Torrance, G.W. (1978). The utility of different health states as perceived by the general public. *Journal of Chronic Diseases* 31, 697-704.

Sadovnick, A.D. and Baird, P.A. (1981). A cost-benefit analysis of prenatal detection of Down syndrome and neural tube defects in older mothers. *Am J Med Genet* 10, 367-378.

Sassone, P.G. and Schaffer, W.A. (1978). *Cost-benefit analysis. A handbook*. Academic Press, New York.

Scheckler, W.E. (1980). Hospital costs of nosocomial infections : a prospective 3-month study in a community hospital. *Infection Control* 1 (3), 150-152.

Schoemaker, P.J.H. (1980). *Experiments on decisions under risk: the expected utility hypothesis*. Nijhoff Publishing Co., Boston, Mass., USA.

Schoemaker, P.J.H. (1982). The expected utility model: its variants, purposes, evidence and limitations. *Journal of Economic Literature* 20, 529-563.

Shepherd, R.W., Holt, T.L., Thomas, B.J., Kay, L., Isles, A., Francis, P.J., and Ward, L.C. (1986). Nutritional rehabilitation in cystic fibrosis: Controlled studies of effects on nutritional growth retardation, body protein turnover, and course of pulmonary disease. *Journal of Pediatrics* 109 (5), 788-794.

Shwachman, H. and Kulczycki, L.L. (1958). Long-term study of one hundred five patients with cystic fibrosis. *American Journal of Diseases of Children* 96, 6-15.

Simmonds, E.J., Littlewood, J.M., and Evans, E.G.V. (1990). Cystic fibrosis and allergic bronchopulmonary aspergillosis. *Archives of Disease in Childhood* 65, 507-511.

Siskind, F.B. (1987). The cost of compensating asbestos victims under the Occupational Disease Compensation Act of 1983. *Risk Anal* 7, 59-69.

Sivan, Y., Arce, P., Eigen, H., Nickerson, B.G., and Newth, C.J.L. (1990). A double-blind, randomized study of sodium cromoglycate versus placebo in patients with cystic fibrosis and bronchial hyperreactivity. *Journal of Allergy and Clinical Immunology* 85, 649-654.

Smith, A.L. (1986). Antibiotic therapy in cystic fibrosis: Evaluation of clinical trials. *Journal of Pediatrics* 108 (5), 866-870.

Soni, R.K. and Cavendish, M.E. (1984). A review of the Liverpool elbow prosthesis from 1974 to 1982. *Journal of Bone and Joint Surgery* 66-B (2), 248-253.

Sorkin, A.L. (1975). *Health economics*. D.C. Heath and Company.

Spengler, R.F. and Greenough, W.B. (1978). Hospital costs and mortality attributed to nosocomial bacteremias. *Journal of the American Medical Association* 240, 2455-2458.

Spitzer, W.O., Dobson, A.J., Hall, J., Chesterman, E., Levi, J., Shepherd, R., Battista, R.N., and Catchlove, B.R. (1981). Measuring the quality of life of cancer patients: a concise QL-Index for use by physicians. *Journal of Chronic Diseases* 34, 585-597.

Stafanger, G. and Koch, C. (1989). N-acetylcysteine in cystic fibrosis and *Pseudomonas aeruginosa* infection: clinical score, spirometry and ciliary motility. *Eur Respir J* 2, 234-237.

Stason, W.B. and Weinstein, M.C. (1977). Allocation of resources to manage hypertension. *New England Journal Of Medicine* 296 (13), 732-739.

Stead, R.J., Hodson, M.E., and Batten, J.C. (1987). Inhaled ceftazidime compared with gentamicin and carbenicillin in older patients with cystic fibrosis infected with *Pseudomonas aeruginosa*. *Br J Dis Chest* 81 (3), 272-279.

Steen, H.J., Scott, E.M., Stevenson, M.I., Black, A.E., Redmond, A.O.B., and Collier, P.S. (1989). Clinical and pharmacokinetic aspects of ciprofloxacin in the treatment of acute exacerbations of pseudomonas infection in cystic fibrosis patients. *Journal of Antimicrobial Chemotherapy* 24, 787-795.

Steiner, K. and Smith, H. (1973). Application of cost benefit analysis to a PKU screening program. *Inquiry* 10, 34.

Stevenson, R. (1991). The Oregon formula: health economists' dream or Stalinist nightmare? *Archives of Disease in Childhood* 66, 990-993.

Strandvik, B. (1988). Antibiotic therapy of pulmonary infections in cystic fibrosis. Dosage schedules and duration of treatment. *Chest* 94 (2), 146S-149S.

Strandvik, B. (1988). Home treatment of pulmonary infections in cystic fibrosis. Discussion. *Chest* 94 (2), 166S.

Strandvik, B., Malmborg, A.S., Alfredson, H., and Ericsson, A. (1983). Clinical results and pharmacokinetics of ceftazidime treatment in patients with cystic fibrosis. *Journal of Antimicrobial Chemotherapy* 12 (Suppl A), 283-287.



Taplin, S.H., Thompson, R.S., and Conrad, D.A. (1988). Cost-justification analysis of prenatal maternal serum alpha-feto protein screening. *Medical Care* 26, 1185-1202.

Taussig, L.M., Kattwinkel, J., Friedewald, W.T., and Di Sant'Agnese, P.A. (1973). A new prognostic score and clinical evaluation system for cystic fibrosis. *Journal of Paediatrics* 82 (3), 380-388.

Taussig, L.M., Lobeck, C.C., di Sant'Agnese, P.A., Ackerman, D.R., and Kattwinkel, J. (1972). Fertility in males with cystic fibrosis. *New England Journal of Medicine* 287 (12), 586-589.

Thompson, M.S., Read, J.L., and Liang, M. (1984). Feasibility of willingness-to-pay measurement in chronic arthritis. *Medical Decision Making* 4 (2), 195-215.

Toevs, C.D., Kaplan, R.M., and Atkins, C.J. (1984). The costs and effects of behavioral programs in chronic obstructive pulmonary disease. *Medical Care* 22, 1088-1100.

Torrance, G.W. (1986). Measurement of health state utilities for economic appraisal. *Journal of Health Economics* 5, 1-30.

Torrance, G.W., Boyle, M.H., and Horwood, S.P. (1982). Application of multi-attribute utility theory to measure social preferences for health states. *Operations Research* 30 (6), 1043-1069.

Torrance, G.W., Thomas, W.H., and Sackett, D.L. (1972). A utility maximization model for evaluation of health care programmes. *Health Services Research* 7 (2), 118-133.

Torrance, G.W. and Zipursky, A. (1984). Cost-effectiveness of ante-partum prevention of Rh immunization. *Clinics in Perinatology* 11 (2), 267-281.

Turck, D., Boute, O., Ythier, H., Gottrand, F., Loeuille, G.A., and Farriaux, J.P. (1989). Anomalie de la permeabilite intestinale a l'EDTA-Cr dans la mucoviscidose. *Arch Fr Pediatr* 46, 425-428.

Van der Laag, J. (1988). Antimicrobial therapy against staphylococcus aureus, Pseudomonas aeruginosa, and Pseudomonas cepacia. Discussion. *Chest* 94 (2), 145S.

Van Grouw, A., Nadel, C.I., Weierman, R.J., and Lowell, H.A. (1976). Long term follow-up of patients with idiopathic scoliosis treated surgically. *Clinical Orthopaedics and Related Research* 117, 197-201.

Von Neumann, J. and Morgenstern, O. (1947). *Theory of games and economic behaviour* 2nd. Edn. Princeton University Press.

Wall, M.A., Terry, A.B., Eisenberg, J., McNamara, M., and Cohen, R. (1983). Inhaled antibiotics in cystic fibrosis. *Lancet* 1, 1325.

Ward, R.A. (1975). *The economics of health resources*. Addison-Wesley.

Warner, K.E. and Luce, B.R. (1982). *Cost-benefit and cost-effectiveness analysis in health care. Principles, practice, and potential*. Health Administration Press, Ann Arbor, Michigan.

Warwick, W.J. (1982). Prognosis for survival with cystic fibrosis: The effects of early diagnosis and cystic fibrosis center care. *Acta Paediatr Scand* 301 (suppl), 27-31.

Weinstein, M.C. (1980). Estrogen use in postmenopausal women - costs, risks and benefits. *New England Journal of Medicine* 303 (6), 308-316.

Weinstein, M.C. (1981). Economic assessment of medical practices and technologies. *Medical Decision Making* 1 (4), 309-330.

Weinstein, M.C. (1986). Risky choices in medical decision making: a survey. *The Geneva Papers on Risk and Insurance* 11 (4), 197-216.

Weinstein, M.C. and Fineberg, H.V. (1980). *Clinical decision analysis*. W.B. Saunders, Philadelphia.

Weinstein, M.C., Pliskin, J.S., and Stason, W.B. (1977). Coronary artery bypass surgery: decision and policy analysis. In *Costs, risks and benefits of surgery* (eds J.P. Bunker, B.A. Barnes and F. Mosteller), pp 342-371. Oxford University Press, New York.

Weinstein, M.C. and Quinn, R.J. (1983). Psychological considerations in valuing health risk reductions. *Journal of Natural Resources* 23, 659-673.

Weinstein, M.C. and Stason, W.B. (1976). *Hypertension: a policy perspective*. Harvard University Press, Cambridge, Mass., USA.

Weinstein, M.C. and Stason, W.B. (1977). Foundations of cost-effectiveness analysis in health and medical practices. *New England Journal of Medicine* 296 (13), 716-721.

Weinstein, M.C. and Stason, W.B. (1982). Cost-effectiveness of coronary artery bypass surgery. *Circulation* 66 (III), 56-66.

Weintraub, S.J. and Eschenbacher, W.L. (1989). The inhaled bronchodilators ipratropium bromide and metaproterenol in adults with CF. *Chest* 95 (4), 861-864.

Wientzen, R., Prestidge, C.B., Kramer, R.I., McCracken, G.H., and Nelson, J.D. (1980). Acute pulmonary exacerbations in cystic fibrosis. *Am J Dis Child* 134, 1134-1138.

Williams, A. (1985). Economics of coronary artery bypass grafting. *British Medical Journal* 291, 326-329.

Williams, A. (1989). Comment on 'Should QALYs be programme specific?' *Journal of Health Economics* 8, 485-487.

Wilmott, R.W., Tyson, S.L., Dinwiddie, R., and Matthew, D.J. (1983). Survival rates in cystic fibrosis. *Archives of Disease in Childhood* 58 (10), 835-836.

Wilmott, R.W., Tyson, S.L., and Matthew, D.J. (1985). Cystic fibrosis survival rates. The influences of allergy and *Pseudomonas aeruginosa*. *AJDC* 139, 669-671.

World Health Organization (1947). The constitution of the World Health Organization. *WHO Chron* 1, 29.

Wright, M.L. and Elsas, L.J. (1980). Application of benefit-to-cost analysis to an X-linked recessive cardiac and humeroperoneal neuromuscular disease. *Am J Med Genet* 6, 315-329.

# TECHNICAL APPENDIX



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ANNOTATED BIBLIOGRAPHY OF HEALTH STATUS  
MEASUREMENT LITERATURE

1) Acton, J.P. (1973). *Evaluating public programs to save lives. The case of heart attacks*. Rand Corporation, R-73-02, Santa Monica, California, USA.

Application of willingness to pay approach to measure health status in a study of life-saving techniques for victims of sudden heart attacks.

2) Bergner, M., Bobbitt, R.A., Kressel, S., Pollard, W.E., Gilson, B.S., and Morris, J.R. (1976). The Sickness Impact Profile: conceptual formulation and methodology for the development of a health status measure. *International Journal Of Health Services* 6, 393-415.

The Sickness Impact Profile, based on the concept of health-related dysfunction, is an outcome measure derived from quantitative estimates of changes in the behaviour of respondents. It has 312 items in 14 categories.

3) Boyle, M.H., Torrance, G.W., Sinclair, J.C., and Horwood, S.P. (1983). Economic evaluation of neonatal intensive care of very-low-birth-weight infants. *New England Journal Of Medicine* 308 (22), 1330-1337.

Application of cost-utility analysis to neonatal intensive care of very-low-birth-weight infants. Utilities are measured by rating scale. Wide range of costs taken into account on the cost side.

4) Breslow, L. (1972). A quantative approach to the world health organization definition of health: physical, mental and social well-being. *International Journal Of Epidemiology* 1, 347-355.

The self-administered questionnaire of the Alameda County Human Population Laboratory yields 3 separate scores for physical, mental and social health. It has been used successfully in representative samples of general populations.

5) Breyer, F. and Fuchs, V.R. (1982). *Risk attitudes in health: an exploratory study*. NBER Working Paper No.875, Cambridge, M.A.

Standard gamble approach used to investigate whether the typical patterns of decision-making under uncertainty carry over from choices among monetary aspects to the health dimension.



6) Bulpitt, C.J. and Fletcher, A.E. (1990). The measurement of quality of life in hypertensive patients: a practical approach. *Br J Clin Pharmac* 30, 353-364.

The authors describe a new health status index which measures the effects of antihypertensive treatment on the health-related quality of life of hypertensive patients.

7) Bush, J.W., Chen, M.M., and Patrick, D.L. (1973). Health status index in cost-effectiveness: analysis of PKU programme. In *Health status indexes* (ed. R.L. Berg), pp 172-194. Hospital Research and Educational Trust, Chicago.

Application of cost-utility analysis to PKU screening. Utilities are measured by rating scale. Only direct costs are taken into account on the cost side.

8) Buxton, M., Ashby, J., and O'Hanlon, M. (1986). *Valuation of health states using the time trade-off approach: report of a pilot study relating to health states one year after treatment for breast cancer*. HERG Discussion Paper No.2., Brunel University.

Ranking and time trade-off approaches incorporated within an interview to obtain valuations for scenarios describing the health states of women after treatment for breast cancer.

9) Culyer, A.J. (1978). *Measuring health: lessons for Ontario*. Ontario Economic Council, Toronto, Canada.

A useful guide to the health measurement literature which is related to Ontario's current and prospective policy choices and to the federal context of health indicator development.

10) Drummond, M.F. (1989). Output measurement for resource allocation decisions in health care. *Oxford Review Of Economic Policy* 5 (1), 59-74.

A review of the contribution that existing output measures make, or could make, to resource allocation decisions in health care.

11) Drummond, M.F., Stoddart, G.L., and Torrance, G.W. (1987). *Methods for the economic evaluation of health care programmes*. Oxford University Press.

Excellent review of the practical methodological issues that health-care evaluators need to resolve in undertaking an economic evaluation.

12) Edwards, W. (1977). How to use multiattribute utility measurement for social decision making. *IEEE Transactions On Systems, Man And Cybernetics* 7, 326-340.

Edwards produces a simplified multiattribute rating technique.

13) Elstein, A.S., Holzman, G.B., Ravitch, M.M., Metheny, W.A., Holmes, M.M., Hoppe, R.B., Rotherth, M.L., and Rovner, D.R. (1986). Comparison of physicians decisions regarding estrogen replacement therapy for menopausal women and decisions derived from a decision analytic model. *The American Journal Of Medicine* 80., 246-258.

This study incorporates both decision analysis and measurement techniques (rating scale and standard gamble approach) in an analysis of estrogen replacement therapy for menopausal women.

14) Eraker, S.A. and Sox, H.C. (1981). Assessment of patients preferences for therapeutic outcomes. *Medical Decision Making* 1 (1), 29-39.

Standard gamble approach used to analyze patients' responses to hypothetical therapeutic scenarios in drug therapy decisions with uncertain outcomes.

15) Euroqol Group. (1990). Euroqol - a new facility for the measurement of health-related quality of life. *Health Policy* 16 (3), 199-208.

An early report of the development of a new health status index, the Euroqol instrument. Not a sophisticated index - it only contains six parameters (mobility, self-care, main activity, social relationships, pain and mood), each of which contains three categories.

16) Gafni, A. and Torrance, G. (1984). Risk attitudes and time preferences in health. *Management Science* 30 (4), 440-451.

This paper reviews and explores the application of the concepts of risk attitude and time preference to the field of health.

17) Grogono, A.W. and Woodgate, D.J. (1971). Index for measuring health. *Lancet* 2, 1024-1026.

Grogono and Woodgate develop an index to measure health with 10 items focussing mainly on physical function.

18) Gudex, C. (1986). *QALY's and their use by the health service*. University Of York, Centre For Health Economics, Discussion Paper 20.

An important discussion paper which describes how the cost utility approach can be used to allocate health care resources. The calculation of cost utility estimates for seven medical procedures illustrate the approach.

19) Harris, A.I., Cox, E., and Smith, C.R.W. (1971). *Handicapped and impaired in Great Britain*. HMSO, London.

The Harris Index seeks to measure degrees of physical, mental, and sensory handicap in the population by measuring subjects.

20) Hunt, S.M., McEwen, J., and McKenna, S.P. (1985). Measuring health status: a new tool for clinicians and epidemiologists. *Journal of the Royal College of General Practitioners* 35, 185-188.

The development and characteristics of the Nottingham Health Profile is described. This health status index is divided into two parts, each of which is weighted to give a total score of 100.

21) Hutchinson, T.A., Boyd, N.F., Feinstein, A.R., Gonda, A., Hollomby, D., and Rowat, B. (1979). Scientific problems in clinical scales, as demonstrated in the Karnofsky Index of Performance Status. *Journal Of Chronic Diseases* 32, 661-666.

An outline of the methodological problems in using ad hoc numeric scales as a means of measuring health status.

22) Izsak, F.C. and Medalie, J.H. (1971). Comprehensive follow-up of carcinoma patients. *Journal Of Chronic Diseases* 24, 179-191.

Izsak and Medalies' 'Ability Index' integrates 21 items covering physical, emotional, social and economic factors to produce a single score measuring health. It is modified for each type of cancer.

23) Kahneman, D. and Tversky, A. (1979). Prospect theory: an analysis of decision under risk. *Econometrica* 47 (2), 263-291.

This paper presents a critique of expected utility theory as a descriptive model of decision making under risk, and develops an alternative model, called prospect theory.

- 24) Kaplan, R.M. and Bush, J.W. (1982). Health-related quality of life measurement for evaluation research and policy analysis. *Health Psychology* 1 (1), 61-80.

Excellent review of the ten years of work by Bush, Kaplan, and colleagues at the University of California, San Diego, on health status measurement.

- 25) Kaplan, R.M., Bush, J.W., and Berry, C.C. (1976). Health status. Types of validity and the index of well-being. *Health Services Research* 11 (4), 478-507.

Kaplan et al construct the Index of Well-being to fulfil the definition of content validity by including all levels of function and symptom/problem complexes, a clearly defined relation to the death state, and consumer ratings of the relative desirability of the function levels.

- 26) Kaplan, R.M., Bush, J.W., and Berry, C.C. (1979). Health status index. Category rating versus magnitude estimation for measuring levels of well-being. *Medical Care* 17 (5), 501-525.

Kaplan et al create a health index with two components: level of well-being and prognosis, the latter being the probability of attaining a level of well-being by a certain time.

- 27) Karnofsky, D.A., Abelmann, W.H., Craver, L.F., and Burchenal, J.H. (1948). The use of the nitrogen mustards in the palliative treatment of carcinoma, with particular reference to bronchogenic carcinoma. *Cancer*, 634-656.

The Karnofsky Index is used to analyze the use of the nitrogen mustards in the palliative treatment of carcinoma with particular reference to bronchogenic carcinoma.

- 28) Karnofsky, D.A. and Burchenal, J.H. (1949). The clinical evaluation of chemo-therapeutic agents in cancer. In *Evaluation of chemotherapeutic agents* (ed C.M. Macleod), pp 191-205. Columbia University Press, New York.

An early ad hoc numeric scale to measure health status designed for use in cancer research based on an interpretation of health-related quality of life in terms of physical ability.

29) Katz, S. (1987). The Portugal Conference: measuring quality of life and functional status in clinical and epidemiological research. *Journal Of Chronic Diseases: Forum For Clinical Epidemiology*.

A thorough review of the issues involved in measuring health-related quality of life.

30) Katz, S. and Akpom, C.A. (1976). A measure of primary sociobiological functions. *International Journal Of Health Services* 6, 493-507.

The Katz ADL Index is probably the best example of a scale created for a variety of diagnoses to measure health status. It measures the basic sociobiological functions of bathing, dressing, toileting, transfer, continence and feeding.

31) Keeney, R.L. and Raiffa, H. (1976). *Decisions with multiple objectives. Preferences and value tradeoffs*. Wiley Publications, New York.

Useful though complicated text on decision analysis. Comprehensive coverage of single-attribute and multi-attribute utility theory. Quite mathematical and heavy in parts.

32) Kind, P., Rosser, R., and Williams, A. (1982). Valuation of quality of life: some psychometric evidence. In *The value of life and safety* (ed M.W. Jones-Lee), pp 159-170. Amsterdam: Elsevier/North Holland.

An outline of a method by which a rough tariff for valuing distress and disability might be established in the form of a set of coefficients could be used to estimate the compensation due for various states intermediate between fit and dead.

33) Klarman, H.E. (1982). The road to cost-effectiveness analysis. *Milbank Memorial Fund Quarterly* 60 (4), 585-603.

The author describes four broad areas which favour cost effectiveness analysis over cost benefit analysis: problems in economic valuation, determining programme outcomes, calculating programme costs and concern for distributional effects.

34) McNeil, B.J., Pauker, S.G., Sox, H.C., and Tversky, A. (1982). On the elicitation of preferences for alternative therapies. *New England Journal Of Medicine* 306 (21), 1259-1262.

An interesting investigation on how variations in the way information is presented to patients influence their choices between alternative therapies.

35) McNeil, B.J., Weichselbaum, R., and Pauker, S.G. (1978). Fallacy of the five-year survival in lung cancer. *New England Journal Of Medicine* 299 (25), 1397-1401.

Standard gamble approach incorporated in study designed to illustrate the importance of evaluating therapeutic results with an index that includes explicit consideration of patient attitudes toward risk.

36) McNeil, B.J., Weichselbaum, R., and Pauker, S.G. (1981). Tradeoffs between quality and quantity of life in laryngeal cancer. *New England Journal Of Medicine* 305 (17), 982-987.

This paper uses the standard gamble and time trade-off approaches to measure patients' attitudes toward the quality and quantity of life to develop a more precise index of the relative values of alternative treatments.

37) Muller, A. and Reutzel, T.J. (1984). Willingness to pay for reduction in fatality risk: an exploratory survey. *American Journal Of Public Health* 74 (8), 808-812.

An outline of the practical difficulties of using the willingness to pay approach to measure health status.

38) Patrick, D.L., Bush, J.W., and Chen, M.M. (1973). Toward an operational definition of health. *Journal Of Health And Social Behaviour* 14, 6-23.

Patrick et al measure the perceived social values of defined functional levels of health. This socially-weighted system of function levels was then used in the construction of a health status index.

39) Pauker, S.G. (1976). Coronary artery surgery: the use of decision analysis. *Annals Of Internal Medicine* 85, 8-18.

This paper illustrates how decision analysis can be used as an aid in the management of individual patients with chronic ischemic heart disease.

40) Pauker, S.G. and McNeil, B.J. (1981). Impact of patient preferences on the selection of therapy. *Journal Of Chronic Disability* 34, 77-86.

Pauker and McNeil adopt the techniques of utility theory to integrate patient preferences with objective survival data. The importance of variations in patient attitudes toward survival is illustrated in a typical situation involving the choice between medical and surgical therapy.

41) Pauker, S.P. and Pauker, S.G. (1977). Prenatal diagnosis: a directive approach to genetic counselling using decision analysis. *Yale Journal Of Biology And Medicine* 50, 275-289.

The decision which prospective parents face concerning mid-trimester amniocentesis for prenatal diagnosis was examined by decision analysis.

42) Pliskin, J.S., Shepard, D.S., and Weinstein, M.C. (1980). Utility functions for life years and health status. *Operations Research* 28, 206-224.

Measurement techniques (standard gamble and time trade-off approaches) are applied to the treatment decision of whether to prescribe coronary artery bypass graft surgery in patients with coronary artery disease.

43) Pliskin, J.S., Stason, W.B., Weinstein, M.C., Johnson, R.A., Cohn, P.F., McEnany, M.T., and Braun, P. (1981). Coronary artery bypass graft surgery. Clinical decision making and cost-effectiveness analysis. *Medical Decision Making* 1 (1), 10-28.

Decision-analytic techniques used to evaluate the choice between an aortocoronary bypass operation and medical management in a set of hypothetical patients with coronary artery disease.

44) Raiffa, H. (1969). *Preferences for multiattributed alternatives*. Rand Corporation, RM-5868-DOT/RC, Santa Monica, California, USA.

Useful background text in decision analysis, focussing on the method of multiattributed utility functions.

45) Read, J.L., Quinn, R.J., Berwick, D.M., Fineberg, H.V., and Weinstein, M.C. (1984). Preferences for health outcomes: comparison of assessment methods. *Medical Decision Making* 4 (3), 315-329.

This study compared standard gamble, time trade-off, and category scaling methods for assessing preferences among hypothetical outcomes of coronary artery bypass surgery.

46) Rosser, R.M. and Kind, P. (1978). A scale of valuations of states of illness: is there a social consensus? *International Journal Of Epidemiology* 7 (4), 347-358.

A ratio scale of valuations of states of illness is derived and applied to health indicators and output measures.

47) Rosser, R.M. and Watts, V. (1975). A clinical classification of disability and distress and its application to the awards made by the courts in personal injury cases. *New Law Journal* 125, 323-328.

Rosser and Watts measure the willingness to receive as determined by court awards for disabilities in order to develop a ratio scale for health states.

48) Sackett, D.L., Chambers, L.W., Macpherson, A.S., Goldsmith, C.H., and McAuley, R.G. (1977). The development and application of indices of health: general methods and a summary of results. *American Journal Of Public Health* 67, 423-428.

The Health Index from McMaster University measures social, emotional and physical function of persons with a wide range of health problems.

49) Sackett, D.L. and Torrance, G.W. (1978). The utility of different health states as perceived by the general public. *Journal of Chronic Diseases* 31, 697-704.

This study calculates social utility values for 10 different health states with varying physical, social and emotional characteristics, limitations and duration.

50) Schoemaker, P.J.H. (1980). *Experiments on decisions under risk: the expected utility hypothesis*. Nijhoff Publishing Co., Boston, Mass., USA.

This paper illustrates the typical patterns of decision-making under uncertainty.

51) Schoemaker, P.J.H. (1982). The expected utility model: its variants, purposes, evidence and limitations. *Journal Of Economic Literature* 20, 529-563.

This paper reviews the major empirical studies bearing on the expected utility model.



52) Spitzer, W.O., Dobson, A.J., Hall, J., Chesterman, E., Levi, J., Shepherd, R., Battista, R.N., and Catchlove, B.R. (1981). Measuring the quality of life of cancer patients: a concise QL-Index for use by physicians. *Journal Of Chronic Diseases* 34, 585-597.

The study attempts to provide a new measure, the Spitzer QL-Index, that can help physicians assess the relative benefits and risks of various treatments for serious illness and of supportive programmes such as palliative care or hospice care.

53) Stason, W.B. and Weinstein, M.C. (1977). Allocation of resources to manage hypertension. *New England Journal Of Medicine* 296 (13), 732-739.

Application of cost-utility analysis to hypertension. Hypothetical utilities used. Only direct costs are taken into account.

54) Thompson, M.S., Read, J.L., and Liang, M. (1984). Feasibility of willingness-to-pay measurement in chronic arthritis. *Medical Decision Making* 4 (2), 195-215.

Application of willingness to pay approach to measure health status to patients with chronic arthritis.

55) Torrance, G.W. (1986). Measurement of health state utilities for economic appraisal. *Journal Of Health Economics* 5, 1-30.

An excellent and thorough review of health status measurement for use in economic appraisal of health care programmes, with particular emphasis on utility measurement.

56) Torrance, G.W., Boyle, M.H., and Horwood, S.P. (1982). Application of multi-attribute utility theory to measure social preferences for health states. *Operations Research* 30 (6), 1043-1069.

A presentation of a four-attribute health state classification system designed to uniquely categorize the health status of all individuals two years of age and over.

57) Torrance, G.W., Thomas, W.H., and Sackett, D.L. (1972). A utility maximization model for evaluation of health care programmes. *Health Services Research* 7 (2), 118-133.

The original cost-utility model as first developed. Takes a society-wide view of costs though flexible enough to substitute other cost definitions.

58) Torrance, G.W. and Zipursky, A. (1984). Cost-effectiveness of ante-partum prevention of Rh immunization. *Clinics In Perinatology* 11 (2), 267-281.

A recent cost-utility study. Only direct costs and benefits considered. Undertaken from the viewpoint of the health care sector. It does however give a listing of cost-utility results from other studies.

59) Von Neumann, J. and Morgenstern, O. (1947). *Theory of games and economic behaviour* 2nd. Edn. Princeton University Press.

An early text on how the theory of games can be applied to economic behaviour.

60) Weinstein, M.C. (1980). Estrogen use in postmenopausal women - costs, risks and benefits. *New England Journal Of Medicine* 303 (6), 308-316.

Application of cost-utility analysis to estrogen therapy. Hypothetical utilities used. Only direct costs are taken into account.

61) Weinstein, M.C. (1981). Economic assessment of medical practices and technologies. *Medical Decision Making* 1 (4), 309-330.

A review of cost-effectiveness analyses in health care, highlighting some common pitfalls and unresolved controversies.

62) Weinstein, M.C. (1986). Risky choices in medical decision making: a survey. *The Geneva Papers On Risk And Insurance* 11 (4), 197-216.

Weinstein outlines the theory and application of decision analysis as a prescriptive tool in medical decision making and allocation of health care resources.

63) Weinstein, M.C. and Fineberg, H.V. (1980). *Clinical decision analysis*. W.B. Saunders, Philadelphia.

A useful background text on clinical decision analysis.

64) Weinstein, M.C., Pliskin, J.S., and Stason, W.B. (1977). Coronary artery bypass surgery: decision and policy analysis. In *Costs, risks and benefits of surgery* (eds J.P. Bunker, B.A. Barnes and F. Mosteller), pp 342-371. Oxford University Press, New York.

Application of cost-utility analysis to coronary artery bypass surgery. Hypothetical utilities used. Only direct costs are taken into account.

65) Weinstein, M.C. and Quinn, R.J. (1983). Psychological considerations in valuing health risk reductions. *Journal Of Natural Resources* 23, 659-673.

Weinstein and Quinn discuss to what extent the contextual and psychological attributes of a risky decision have sufficient normative status to justify their formal inclusion in methods for valuing risk.

66) Weinstein, M.C. and Stason, W.B. (1976). *Hypertension: a policy perspective*. Harvard University Press, Cambridge, Mass., USA.

Weinstein and Stason use hypertension to demonstrate the usefulness of systematic policy analysis in addressing the issues of resource allocation that surround a complex, uncertainty-laden medical detection and treatment problem.

67) Weinstein, M.C. and Stason, W.B. (1982). Cost-effectiveness of coronary artery bypass surgery. *Circulation* 66 (III), 56-66.

Recent data from the medical literature and other sources were used in an analysis of the cost-effectiveness of coronary artery bypass graft surgery in symptomatic patients.

68) Williams, A. (1985). Economics of coronary artery bypass grafting. *British Medical Journal* 291, 326-329.

Application of cost-utility analysis to coronary artery bypass grafting. Private costs ignored. Judgments based on crude data. It does however provide a ranking of various procedures in terms of their cost per quality-adjusted life-year gained.

**HIP JOINT REPLACEMENT SAMPLE - PREOPERATIVE QUESTIONNAIRE**

Title :

Name :

Patient Number :

Address :

Date of birth :

Age :

Sex :

Reason for surgery :

Date of pre-operative interview :

Time of pre-operative interview :

Date of operation :

Height :

Weight :

Occupation :

How would you categorize your present state of health according to the Rosser Disability/Distress Index ?

Would you describe the pain, stiffness and swelling in your hip as

- non-existent ?
  - slight but does not interfere with your daily activities ?
  - moderate and occasionally interferes with your daily activities and occasionally disturbs your sleep ?
  - severe and regularly interferes with your daily activities and regularly disturbs your sleep ?
-

Would you say that at the present time, the state of the hip about to be operated on

- does not affect your performance at work/ability to work ?
  - slightly impairs your performance at work/ability to work ?
  - severely limits your performance at work/ability to work ?
  - means that you are unable to undertake any paid employment ?
- 

Would you say that at the present time, the state of the hip about to be operated on

- means that you are able to undertake all housework/household tasks ?
  - means that you are able to undertake all housework/household tasks except very heavy tasks ?
  - means that you are only able to undertake light housework/household tasks ?
  - means that you are only able to perform a few very simple tasks ?
  - means that you are unable to undertake any housework/household tasks at all ?
- 

Would you say that at the present time, the state of the hip about to be operated on

- does not interfere with your hobbies and leisure activities at all ?
  - slightly interferes with your hobbies and leisure activities ?
  - severely interferes with your hobbies and leisure activities ?
  - completely interferes with your hobbies and leisure activities ?
- 

Would you say that at the present time, the state of the hip about to be operated on

- means that you are totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - means that you occasionally need moderate help from others for acts of daily living ?
  - means that you regularly need crucial help from others for acts of daily living ?
  - means that you are totally dependent on others for acts of daily living ?
-

Would you say that at the present time, the state of the hip about to be operated on

- does not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricts your ability to participate in sports ?
  - severely restricts your ability to participate in sports ?
  - completely restricts your ability to participate in sports ?
- 

Would you say that at the present time, the state of the hip about to be operated on

- does not interfere with your sleeping patterns at all ?
  - slightly interferes with your sleeping patterns ?
  - severely interferes with your sleeping patterns ?
  - completely interferes with your sleeping patterns ?
- 

Would you say that at the present time, the state of the hip about to be operated on

- means that you can walk long distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you can only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you are unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?
- 

Are you able to sleep on the side about to be operated on without noticeable discomfort ?

Are you able to drive/to use public transport without noticeable discomfort ?

Are you able to bend your knees without noticeable discomfort ?

Are you able to walk up a flight of stairs without noticeable discomfort ?

Are you able to go out shopping without assistance ?

Are you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Are you able to have a bath/shower without assistance ?

Can you dress yourself ?

Can you cook a meal without assistance ?

Can you do general housework, e.g., Hoovering, dusting, without assistance ?

Do you need assistance when moving around the house because of your illness ?

Are you confined to a chair or to a wheelchair because of your illness ?

Are you confined to bed for most or all of the day because of your illness ?

**KNEE JOINT REPLACEMENT SAMPLE - PREOPERATIVE QUESTIONNAIRE**

Title :

Name :

Patient Number :

Address :

Date of birth :

Age :

Sex :

Reason for surgery :

Date of pre-operative interview :

Time of pre-operative interview :

Date of operation :

Height :

Weight :

Occupation :

How would you categorize your present state of health according to the Rosser Disability/Distress Index ?

Would you describe the pain, stiffness and swelling in your knee as

- non-existent ?
  - slight but does not interfere with your daily activities ?
  - moderate and occasionally interferes with your daily activities and occasionally disturbs your sleep ?
  - severe and regularly interferes with your daily activities and regularly disturbs your sleep ?
-



Would you say that at the present time, the state of the knee about to be operated on

- does not affect your performance at work/ability to work ?
  - slightly impairs your performance at work/ability to work ?
  - severely limits you performance at work/ability to work ?
  - means that you are unable to undertake any paid employment or to continue any education ?
- 

Would you say that at the present time, the state of the knee about to be operated on

- means that you are able to undertake all housework/household tasks ?
  - means that you are able to undertake all housework/household tasks except very heavy tasks ?
  - means that you are only able to undertake light housework/household tasks ?
  - means that you are only able to perform a few very simple tasks ?
  - means that you are unable to undertake any housework/household tasks at all ?
- 

Would you say that at the present time, the state of the knee about to be operated on

- does not interfere with your hobbies and leisure activities at all ?
  - slightly interferes with your hobbies and leisure activities ?
  - severely interferes with your hobbies and leisure activities ?
  - completely interferes with your hobbies and leisure activities ?
- 

Would you say that at the present time, the state of the knee about to be operated on

- means that you are totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - means that you occasionally need moderate help from others for acts of daily living ?
  - means that you regularly need crucial help from others for acts of daily living ?
  - means that you are totally dependent on others for acts of daily living ?
-

Would you say that at the present time, the state of the knee about to be operated on

- does not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricts your ability to participate in sports ?
  - severely restricts your ability to participate in sports ?
  - completely restricts your ability to participate in sports ?
- 

Would you say that at the present time, the state of the knee about to be operated on

- does not interfere with your sleeping patterns at all ?
  - slightly interferes with your sleeping patterns ?
  - severely interferes with your sleeping patterns ?
  - completely interferes with your sleeping patterns ?
- 

Would you say that at the present time, the state of the knee about to be operated on

- means that you can walk long distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you can only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you are unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?
- 

Are you able to sleep on the side about to be operated on without noticeable discomfort ?

Are you able to drive/to use public transport without noticeable discomfort ?

Are you able to bend your knees without noticeable discomfort ?

Are you able to walk up a flight of stairs without noticeable discomfort ?

Are you able to go out shopping without assistance ?

Are you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Are you able to have a bath/shower without assistance ?

Can you dress yourself ?

Can you cook a meal without assistance ?

Can you do general housework, e.g., Hoovering, dusting, without assistance ?

Do you need assistance when moving around the house because of your illness ?

Are you confined to a chair or to a wheelchair because of your illness ?

Are you confined to bed for most or all of the day because of your illness ?

**HIP JOINT REPLACEMENT SAMPLE - POSTOPERATIVE AND  
RETROSPECTIVE QUESTIONNAIRE**

Title :

Name :

Patient Number :

Address :

Date of birth :

Age :

Sex :

Reason for surgery :

Date of post-operative interview :

Time of post-operative interview :

Date of operation :

Time period between post-operative interview and operation :

Height :

Weight :

Occupation :

How would you categorize your present state of health according to the Rosser Disability/Distress Index ?

Would you describe the pain, stiffness and swelling in your hip as

- non-existent ?
- slight but does not interfere with your daily activities ?
- moderate and occasionally interferes with your daily activities and occasionally disturbs your sleep ?
- severe and regularly interferes with your daily activities and regularly disturbs your sleep ?

-----

Would you say that at the present time, the state of the hip operated on

- does not affect your performance at work/ability to work ?
  - slightly impairs your performance at work/ability to work ?
  - severely limits your performance at work/ability to work ?
  - means that you are unable to undertake any paid employment or to continue any education ?
- 

Would you say that at the present time, the state of the hip operated on

- means that you are able to undertake all housework/household tasks ?
  - means that you are able to undertake all housework/household tasks except very heavy tasks ?
  - means that you are only able to undertake light housework/household tasks ?
  - means that you are only able to perform a few very simple tasks ?
  - means that you are unable to undertake any housework/household tasks at all ?
- 

Would you say that at the present time, the state of the hip operated on

- does not interfere with your hobbies and leisure activities at all ?
  - slightly interferes with your hobbies and leisure activities ?
  - severely interferes with your hobbies and leisure activities ?
  - completely interferes with your hobbies and leisure activities ?
- 

Would you say that at the present time, the state of the hip operated on

- means that you are totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - means that you occasionally need moderate help from others for acts of daily living ?
  - means that you regularly need crucial help from others for acts of daily living ?
  - means that you are totally dependent on others for acts of daily living ?
-

Would you say that at the present time, the state of the hip operated on

- does not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricts your ability to participate in sports ?
  - severely restricts your ability to participate in sports ?
  - completely restricts your ability to participate in sports ?
- 

Would you say that at the present time, the state of the hip operated on

- does not interfere with your sleeping patterns at all ?
  - slightly interferes with your sleeping patterns ?
  - severely interferes with your sleeping patterns ?
  - completely interferes with your sleeping patterns ?
- 

Would you say that at the present time, the state of the hip operated on

- means that you can walk long distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you can only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you are unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?
- 

Are you able to sleep on the side operated on without noticeable discomfort ?

Are you able to drive/to use public transport without noticeable discomfort ?

Are you able to bend your knees without noticeable discomfort ?

Are you able to walk up a flight of stairs without noticeable discomfort ?

Are you able to go out shopping without assistance ?

Are you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Are you able to have a bath/shower without assistance ?

Can you dress yourself ?

Can you cook a meal without assistance ?

Can you do general housework, e.g., Hoovering, dusting, without assistance ?

Do you need assistance when moving around the house because of your illness ?

Are you confined to a chair or to a wheelchair because of your illness ?

Are you confined to bed for most or all of the day because of your illness ?

How would you categorize your state of health prior to your operation according to the Rosser Disability / Distress Index ?

Would you describe the pain, stiffness and swelling in your hip prior to your operation as

- non-existent ?
  - slight but did not interfere with your daily activities ?
  - moderate and occasionally interfered with your daily activities and occasionally disturbed your sleep ?
  - severe and regularly interfered with your daily activities and regularly disturbed your sleep ?
- 

Would you say that prior to your operation, the state of the hip operated on

- did not affect your performance at work/ability to work ?
  - slightly impaired your performance at work/ability to work ?
  - severely limited your performance at work/ability to work ?
  - meant that you were unable to undertake any paid employment or to continue any education ?
- 

Would you say that prior to your operation, the state of the hip operated on

- meant that you were able to undertake all housework/household tasks ?
  - meant that you were able to undertake all housework/household tasks except very heavy tasks ?
  - meant that you were only able to undertake light housework / household tasks ?
  - meant that you were only able to perform a few very simple tasks ?
  - meant that you were unable to undertake any housework / household tasks at all ?
-

Would you say that prior to your operation, the state of the hip operated on

- did not interfere with your hobbies and leisure activities at all ?
  - lightly interfered with your hobbies and leisure activities ?
  - severely interfered with your hobbies and leisure activities ?
  - completely interfered with your hobbies and leisure activities ?
- 

Would you say that prior to your operation, the state of the hip operated on

- meant that you were totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - meant that you occasionally needed moderate help from others for acts of daily living ?
  - meant that you regularly needed crucial help from others for acts of daily living ?
  - meant that you were totally dependent on others for acts of daily living ?
- 

Would you say that prior to your operation, the state of the hip operated on

- did not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricted your ability to participate in sports ?
  - severely restricted your ability to participate in sports ?
  - completely restricted your ability to participate in sports ?
- 

Would you say that prior to your operation, the state of the hip operated on

- did not interfere with your sleeping patterns at all ?
  - slightly interfered with your sleeping patterns ?
  - severely interfered with your sleeping patterns ?
  - completely interfered with your sleeping patterns ?
-



Would you say that prior to your operation, the state of the hip operated on

- meant that you could walk long distances without assistance and without feeling any greater discomfort than you normally would ?
- meant that you could only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
- meant that you were unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?

-----  
Were you able to sleep on the side operated on without noticeable discomfort?

Were you able to drive/to use public transport without noticeable discomfort?

Were you able to bend your knees without noticeable discomfort ?

Were you able to walk up a flight of stairs without noticeable discomfort ?

Were you able to go out shopping without assistance ?

Were you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Were you able to have a bath/shower without assistance ?

Could you dress yourself ?

Could you cook a meal without assistance ?

Could you do general housework, e.g., Hoovering, dusting, without assistance?

Did you need assistance when moving around the house because of your illness ?

Were you confined to a chair or to a wheelchair because of your illness ?

Were you confined to bed for most or all of the day because of your illness?

**KNEE JOINT REPLACEMENT SAMPLE - POSTOPERATIVE AND  
RETROSPECTIVE QUESTIONNAIRE**

Title :

Name :

Patient Number :

Address :

Date of birth :

Age :

Sex :

Reason for surgery :

Date of post-operative interview :

Time of post-operative interview :

Date of operation :

Time period between post-operative interview and operation :

Height :

Weight :

Occupation (or ex-occupation or husband's or parent's occupation) :

How would you categorize your present state of health according to the Rosser Disability/Distress Index ?

Would you describe the pain, stiffness and swelling in your knee as

- non-existent ?
- slight but does not interfere with your daily activities ?
- moderate and occasionally interferes with your daily activities and occasionally disturbs your sleep ?
- severe and regularly interferes with your daily activities and regularly disturbs your sleep ?

-----

Would you say that at the present time, the state of the knee operated on

- does not affect your performance at work/ability to work ?
  - slightly impairs your performance at work/ability to work ?
  - severely limits your performance at work/ability to work ?
  - means that you are unable to undertake any paid employment or to continue any education ?
- 

Would you say that at the present time, the state of the knee operated on

- means that you are able to undertake all housework/household tasks ?
  - means that you are able to undertake all housework/household tasks except very heavy tasks ?
  - means that you are only able to undertake light housework/household tasks ?
  - means that you are only able to perform a few very simple tasks ?
  - means that you are unable to undertake any housework/household tasks at all ?
- 

Would you say that at the present time, the state of the knee operated on

- does not interfere with your hobbies and leisure activities at all ?
  - slightly interferes with your hobbies and leisure activities ?
  - severely interferes with your hobbies and leisure activities ?
  - completely interferes with your hobbies and leisure activities ?
- 

Would you say that at the present time, the state of the knee operated on

- means that you are totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - means that you occasionally need moderate help from others for acts of daily living ?
  - means that you regularly need crucial help from others for acts of daily living ?
  - means that you are totally dependent on others for acts of daily living ?
-

Would you say that at the present time, the state of the knee operated on

- does not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricts your ability to participate in sports ?
  - severely restricts your ability to participate in sports ?
  - completely restricts your ability to participate in sports ?
- 

Would you say that at the present time, the state of the knee operated on

- does not interfere with your sleeping patterns at all ?
  - slightly interferes with your sleeping patterns ?
  - severely interferes with your sleeping patterns ?
  - completely interferes with your sleeping patterns ?
- 

Would you say that at the present time, the state of the knee operated on

- means that you can walk long distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you can only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
  - means that you are unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?
- 

Are you able to sleep on the side operated on without noticeable discomfort ?

Are you able to drive/to use public transport without noticeable discomfort ?

Are you able to bend your knees without noticeable discomfort ?

Are you able to walk up a flight of stairs without noticeable discomfort ?

Are you able to go out shopping without assistance ?

Are you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Are you able to have a bath/shower without assistance ?

Can you dress yourself ?

Can you cook a meal without assistance ?

Can you do general housework, e.g., Hoovering, dusting, without assistance ?

Do you need assistance when moving around the house because of your illness ?

Are you confined to a chair or to a wheelchair because of your illness ?

Are you confined to bed for most or all of the day because of your illness ?

How would you categorize your state of health prior to your operation according to the Rosser Disability / Distress Index ?

Would you describe the pain, stiffness and swelling in your knee prior to your operation as

- non-existent ?
  - slight but did not interfere with your daily activities ?
  - moderate and occasionally interfered with your daily activities and occasionally disturbed your sleep ?
  - severe and regularly interfered with your daily activities and regularly disturbed your sleep ?
- 

Would you say that prior to your operation, the state of the knee operated on

- did not affect your performance at work/ability to work ?
  - slightly impaired your performance at work/ability to work ?
  - severely limited your performance at work/ability to work ?
  - meant that you were unable to undertake any paid employment or to continue any education ?
- 

Would you say that prior to your operation, the state of the knee operated on

- meant that you were able to undertake all housework/household tasks ?
  - meant that you were able to undertake all housework/household tasks except very heavy tasks ?
  - meant that you were only able to undertake light housework/household tasks ?
  - meant that you were only able to perform a few very simple tasks ?
  - meant that you were unable to undertake any housework/household tasks at all ?
-

Would you say that prior to your operation, the state of the knee operated on

- did not interfere with your hobbies and leisure activities at all ?
  - slightly interfered with your hobbies and leisure activities ?
  - severely interfered with your hobbies and leisure activities ?
  - completely interfered with your hobbies and leisure activities ?
- 

Would you say that prior to your operation, the state of the knee operated on

- meant that you were totally independent of others , e.g., home help, a district nurse, family and friends, for all acts of daily living, e.g., washing, eating, dressing and moving ?
  - meant that you occasionally needed moderate help from others for acts of daily living ?
  - meant that you regularly needed crucial help from others for acts of daily living ?
  - meant that you were totally dependent on others for acts of daily living ?
- 

Would you say that prior to your operation, the state of the knee operated on

- did not restrict your ability to participate in sports, e.g., bowls, tennis, athletics, swimming, at all ?
  - slightly restricted your ability to participate in sports ?
  - severely restricted your ability to participate in sports ?
  - completely restricted your ability to participate in sports ?
- 

Would you say that prior to your operation, the state of the knee operated on

- did not interfere with your sleeping patterns at all ?
  - slightly interfered with your sleeping patterns ?
  - severely interfered with your sleeping patterns ?
  - completely interfered with your sleeping patterns ?
-

Would you say that prior to your operation, the state of the knee operated on

- meant that you could walk long distances without assistance and without feeling any greater discomfort than you normally would ?
- meant that you could only walk short distances without assistance and without feeling any greater discomfort than you normally would ?
- meant that you were unable to venture out of the house at all without assistance and without feeling any greater discomfort than you normally would ?

-----

Were you able to sleep on the side operated on without noticeable discomfort?

Were you able to drive/to use public transport without noticeable discomfort?

Were you able to bend your knees without noticeable discomfort ?

Were you able to walk up a flight of stairs without noticeable discomfort ?

Were you able to go out shopping without assistance ?

Were you able to sit down on a chair and get up again without assistance and without noticeable discomfort ?

Were you able to have a bath/shower without assistance ?

Could you dress yourself ?

Could you cook a meal without assistance ?

Could you do general housework, e.g., hoovering, dusting, without assistance?

Did you need assistance when moving around the house because of your illness ?

Were you confined to a chair or to a wheelchair because of your illness ?

Were you confined to bed for most or all of the day because of your illness ?

CHARACTERISTICS AND ROSSER-KIND ESTIMATES OF CONTROL GROUP PATIENTS

Number	Sex	Age (at Operation)	Operation Site	Subject's Original Preop RK Estimate (Rating)	My Original Preop RK Estimate (Rating)	Subject's RK Estimate (Rating) After Three Months	My RK Estimate (Rating) After Three Months	Subject's Retro - spective Preop RK Estimate (Rating)	My Retro - spective Preop RK Estimate (Rating)
1	F	69	Knee	-	VD (0.7)	II-III A (0.985)	III A (0.98)	IVD (0.87)	IV-VD (0.785)
2	F	59	Hip	-	IV-VD (0.785)	IVB (0.956)	IVB-C (0.949)	IVD (0.87)	IV-VD (0.785)
3	F	72	Knee	-	VD (0.7)	IV-VB (0.9455)	IV-VB (0.9455)	VD (0.7)	VD (0.7)
4	M	67	Hip	III C (0.956)	III-IVC-D (0.92)	IIA (0.99)	III A-B (0.976)	III D (0.912)	III D (0.912)
5	F	55	Hip	IV-VD (0.785)	IV-VD (0.785)	IIIB (0.972)	IIIB (0.972)	IVD (0.87)	IV-VD (0.785)
6	M	62	Hip	-	IVD (0.87)	III A (0.98)	III A (0.98)	IVC-D (0.906)	IVC-D (0.906)
7	M	64	Hip	VD (0.7)	VD (0.7)	IVB (0.956)	IVB-C (0.949)	VD (0.7)	VD (0.7)
8	F	67	Hip	VID (0)	V-VID (0.35)	IIIB (0.972)	IIIB (0.972)	VID (0)	V-VID (0.35)
9	F	74	Hip	III C (0.956)	III C (0.956)	IB (0.995)	II B (0.986)	VC (0.9)	VC (0.9)
10	F	82	Knee	III-IVC (0.949)	IVD (0.87)	III-IVB-C (0.9565)	III-IVB (0.964)	VD (0.7)	VD (0.7)



11	F	65	Hip	IV-VC-D (0.853)	IV-VC-D (0.853)	IIIB (0.972)	IIIB (0.972)	IVD (0.87)	IV-VD (0.785)
12	M	43	Hip	IVC (0.942)	IVC (0.942)	IVC (0.942)	IVC (0.942)	IVC (0.942)	IVD (0.87)
13	M	66	Knee	IIIC (0.956)	IIIC (0.956)	IIIB-C (0.964)	IIIB-C (0.964)	IIIC (0.956)	IIIC (0.956)
14	F	75	Hip	IVD (0.87)	IVD (0.87)	IVA (0.964)	IVA (0.964)	VD (0.7)	VD (0.7)
15	F	52	Knee	IVD (0.87)	IVD (0.87)	VA (0.946)	VA (0.946)	VD (0.7)	VD (0.7)
16	F	81	Knee	VD (0.7)	IV-VC-D (0.853)	IVB (0.956)	IVB (0.956)	VD (0.7)	VD (0.7)
17	F	65	Knee	VC-D (0.8)	VD (0.7)	VA-B (0.9405)	VA-B (0.9405)	VD (0.7)	VD (0.7)
18	F	55	Hip	IVD (0.87)	IV-VC-D (0.853)	IVB-C (0.949)	IVB-C (0.949)	IVD (0.87)	IV-VD (0.785)
19	F	80	Knee	VC (0.9)	VC (0.9)	-	-	-	-
20	M	70	Hip	IIID (0.912)	IIID (0.912)	IIIA (0.98)	IIIA (0.98)	IIIC-D (0.934)	IIIC-D (0.934)
21	M	64	Hip	III-IVD (0.891)	IVD (0.87)	IIIB (0.972)	III-IVB (0.964)	IVD (0.87)	IVD (0.87)
22	F	82	Knee	VC (0.9)	VC (0.9)	V-VIB (0.89)	V-VIB (0.89)	VD (0.7)	VD (0.7)
23	M	70	Hip	IV-VD (0.785)	VD (0.7)	IV-VA (0.955)	IV-VA (0.955)	IV-VD (0.785)	IV-VD (0.785)
24	F	59	Knee	IVD (0.87)	IVD (0.87)	-	IVD (0.87)	-	IIIC (0.956)
25	M	73	Hip	IV-VC (0.921)	IV-VC (0.921)	IVA (0.964)	IV-VA (0.955)	IV-VD (0.785)	IV-VD (0.785)

26	F	67	Hip	VD (0.7)	VD (0.7)	VA (0.946)	VA-B (0.9405)	VD (0.7)	VD (0.7)
27	M	58	Knee	IVC (0.942)	IVC (0.942)	IIB (0.986)	IIB (0.972)	VD (0.7)	IV-VD (0.785)
28	F	75	Knee	VC-D (0.8)	VC-D (0.8)	IVA (0.964)	IVA-B (0.96)	VD (0.7)	VD (0.7)
29	F	64	Hip	IVD (0.87)	IVD (0.87)	IIC (0.956)	IIC (0.956)	III-C-D (0.934)	III-C-D (0.934)
30	M	66	Knee	IIIB-D (0.947)	IIC (0.956)	-	IIB (0.986)	-	IV-VD (0.785)
31	M	69	Hip	IVD (0.87)	IVD (0.87)	VC (0.9)	IV-VC (0.921)	IIC (0.956)	IIC (0.956)
32	F	76	Knee	IV-VD (0.785)	IV-VD (0.785)	IVB (0.956)	IVB (0.956)	IV-VD (0.785)	IV-VD (0.785)
33	M	67	Hip	III-IVC-D (0.92)	III-IVC-D (0.92)	IIA-B (0.988)	IIA-B (0.988)	IVD (0.87)	IVD (0.87)
34	M	61	Knee	IIIB (0.972)	IVD (0.87)	VC (0.9)	VC (0.9)	VD (0.7)	IV-VD (0.785)
35	M	67	Knee	IVD (0.87)	IVD (0.87)	-	VC (0.9)	-	IV-VD (0.785)
36	F	87	Knee	VC (0.9)	VC (0.9)	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
37	M	65	Knee	IIIB (0.972)	IIC (0.956)	IIIB-C (0.964)	IIIB-C (0.964)	III-IVC-D (0.92)	III-IVC-D (0.92)
38	F	83	Hip	VC (0.9)	VC (0.9)	-	-	-	-
39	M	73	Hip	IVD (0.87)	IVD (0.87)	-	IIIB (0.972)	-	IVC (0.942)
40	F	52	Knee	III-IVC-D (0.92)	III-IVC-D (0.92)	IA (1)	IA (1)	IVD (0.87)	IIID (0.912)

41	M	78	Hip	IVD (0.87)	IVD (0.87)	IVD (0.87)	VB (0.935)	IV-VB (0.9455)	IIIB (0.972)	IIIC (0.956)
42	M	62	Hip	III-IVC-D (0.92)	III-IVC-D (0.92)	III-IVC-D (0.92)	-	IV-VC (0.921)	-	III-IVC-D (0.92)
43	F	79	Knee	VD (0.7)	VD (0.7)	VD (0.7)	-	-	-	-
44	F	63	Knee	IV-VD (0.785)	IV-VD (0.785)	IV-VD (0.785)	IIIA (0.98)	IIIA-B (0.976)	VD (0.7)	VD (0.7)

**CONTROL GROUP - CHANGE IN RATING SCORES FOR INDIVIDUAL  
QUESTIONS FOR WHOLE GROUP**

Question	Scale	Number of Subjects at the Preoperative Interview	Number of Subjects at the Postoperative Interview	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 11 7 26	8 2 18 1 10 0 1	Chisquare = 59.139 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 5 4 8 1 26	5 0 6 2 4 0 22	Chisquare = 8.153 Significant at the 0.25 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	2 0 5 4 16 1 16 0 0	5 0 11 1 11 2 6 2 0	Chisquare = 12.771 Significant at the 0.05 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	2 0 9 1 17 1 13	11 0 17 1 8 0 3	Chisquare = 19.099 Significant at the 0.005 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	23 0 17 0 4 0 0	24 1 12 0 2 0 0	Chisquare = 2.256 Significant at the 0.75 level

Interference With Sports	1 None	0	2	Chisquare = 9.191 Significant at the 0.1 level
	2 None-Slight	0	0	
	3 Slight	0	4	
	4 Slight-Severe	1	2	
	5 Severe	9	10	
	6 Severe-Compl	0	0	
	7 Complete	34	21	
Interference With Sleep	1 None	4	25	Chisquare = 37.904 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	12	13	
	4 Slight-Severe	4	0	
	5 Severe	19	2	
	6 Severe-Compl	1	0	
	7 Complete	4	0	
Walking	1 Long Distances	0	11	Chisquare = 33.363 Significant at less than the 0.001 level
	2 Long - Short	0	1	
	3 Short Distances	9	17	
	4 Short - House	6	7	
	5 Confined House	29	4	
Sleep on Side	1 Yes	15	29	CS = 12.392 l.t. 0.001 level
	2 No	29	11	
Driving/ Transport	1 Yes	12	27	CS = 14.612 l.t. 0.001 level
	2 No	32	12	
Bending Knees	1 Yes	12	33	CS = 27.388 l.t. 0.001 level
	2 No	32	6	
Stairs	1 Yes	3	32	CS = 47.985 l.t. 0.001 level
	2 No	41	7	
Shopping	1 Yes	17	29	CS = 11.754 l.t. 0.001 level
	2 No	27	9	
Chair Without Discomfort	1 Yes	6	29	CS = 29.869 l.t. 0.001 level
	2 No	38	11	
Bath/ Shower	1 Yes	28	29	CS = 0.755 0.5 level
	2 No	16	11	
Dressing	1 Yes	43	40	CS = 0.920 0.5 level
	2 No	1	0	
Cooking	1 Yes	41	37	CS = 0.015 0.95 level
	2 No	3	3	
Hoovering/ Dusting	1 Yes	28	32	CS = 3.5 0.1 level
	2 No	16	7	
Assistance in house	1 Yes	16	9	CS = 1.926 0.25 level
	2 No	28	31	
Confined to Chair	1 Yes	1	0	CS = 0.920 0.5 level
	2 No	43	40	

**CONTROL GROUP - CHANGE IN RATING SCORES FOR INDIVIDUAL  
QUESTIONS FOR HIP SUBGROUP**

Question	Scale	Number of Subjects at the Preoperative Interview	Number of Subjects at the Postoperative Interview	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 3 5 15	5 2 8 0 7 0 0	Chisquare = 36.596 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 2 4 4 1 12	2 0 4 2 2 0 11	Chisquare = 4.963 Significant at the 0.5 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	0 0 3 2 10 0 8 0 0	2 0 8 0 7 1 3 0 0	Chisquare = 10.005 Significant at the 0.1 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	2 0 0 1 11 0 9	4 0 11 1 4 0 2	Chisquare = 19.375 Significant at less than the 0.001 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	10 0 12 0 1 0 0	16 0 6 0 0 0 0	Chisquare = 4.365 Significant at the 0.25 level

Interference With Sports	1 None	0	1	Chisquare = 7.601 Significant at the 0.25 level
	2 None-Slight	0	0	
	3 Slight	0	3	
	4 Slight-Severe	0	1	
	5 Severe	5	7	
	6 Severe-Compl	0	0	
	7 Complete	18	10	
Interference With Sleep	1 None	2	14	Chisquare = 22.656 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	5	7	
	4 Slight-Severe	3	0	
	5 Severe	11	1	
	6 Severe-Compl	0	0	
	7 Complete	2	0	
Walking	1 Long Distances	0	7	Chisquare = 17.679 Significant at the 0.005 level
	2 Long - Short	0	1	
	3 Short Distances	5	8	
	4 Short - House	4	4	
	5 Confined House	14	2	
Sleep on Side	1 Yes	5	14	CS = 8.091 0.005 level
	2 No	18	8	
Driving/ Transport	1 Yes	7	18	CS = 13.672 l.t. 0.001 level
	2 No	16	3	
Bending Knees	1 Yes	9	18	CS = 10.047 0.005 level
	2 No	14	3	
Stairs	1 Yes	2	19	CS = 29.427 l.t. 0.001 level
	2 No	21	2	
Shopping	1 Yes	11	18	CS = 7.013 0.01 level
	2 No	12	3	
Chair Without Discomfort	1 Yes	3	18	CS = 21.369 l.t. 0.001 level
	2 No	20	4	
Bath/ Shower	1 Yes	17	18	CS = 0.407 0.75 level
	2 No	6	4	
Dressing	1 Yes	22	22	CS = 0.978 0.5 level
	2 No	1	0	
Cooking	1 Yes	23	22	CS = 0
	2 No	0	0	
Hoovering/ Dusting	1 Yes	14	19	CS = 5.132 0.025 level
	2 No	9	2	
Assistance in house	1 Yes	10	6	CS = 1.289 0.5 level
	2 No	13	16	
Confined to Chair	1 Yes	1	0	CS = 0.978 0.5 level
	2 No	22	22	

**CONTROL GROUP - CHANGE IN RATING SCORES FOR INDIVIDUAL  
QUESTIONS FOR KNEE SUBGROUP**

Question	Scale	Number of Subjects at the Preoperative Interview	Number of Subjects at the Postoperative Interview	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 8 2 11	3 0 10 1 3 0 1	Chisquare = 26.532 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 3 0 4 0 14	3 0 2 0 2 0 11	Chisquare = 4.020 Significant at the 0.5 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	2 0 2 2 6 1 8 0 0	3 0 3 1 4 1 3 2 0	Chisquare = 5.04 Significant at the 0.75 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 9 0 6 1 4	7 0 6 0 4 0 1	Chisquare = 10.724 Significant at the 0.05 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	13 0 5 0 3 0 0	8 1 6 0 2 0 0	Chisquare = 2.085 Significant at the 0.75 level



Interference With Sports	1 None	0	1	Chisquare = 2.677 Significant at the 0.75 level
	2 None-Slight	0	0	
	3 Slight	0	1	
	4 Slight-Severe	1	1	
	5 Severe	4	3	
	6 Severe-Compl	0	0	
	7 Complete	16	11	
Interference With Sleep	1 None	2	11	Chisquare = 15.614 Significant at the 0.01 level
	2 None-Slight	0	0	
	3 Slight	7	6	
	4 Slight-Severe	1	0	
	5 Severe	8	1	
	6 Severe-Compl	1	0	
	7 Complete	2	0	
Walking	1 Long Distances	0	4	Chisquare = 15.928 Significant at the 0.005 level
	2 Long - Short	0	0	
	3 Short Distances	4	9	
	4 Short - House	2	3	
	5 Confined House	15	2	
Sleep on Side	1 Yes	10	15	CS = 5.372 0.025 level
	2 No	11	3	
Driving/ Transport	1 Yes	5	9	CS = 2.889 0.1 level
	2 No	16	9	
Bending Knees	1 Yes	3	15	CS = 18.594 l.t. 0.001 level
	2 No	18	3	
Stairs	1 Yes	1	13	CS = 19.168 l.t. 0.001 level
	2 No	20	5	
Shopping	1 Yes	6	11	CS = 4.962 0.05 level
	2 No	15	6	
Chair Without Discomfort	1 Yes	3	11	CS = 9.235 0.005 level
	2 No	18	7	
Bath/ Shower	1 Yes	11	11	CS = 0.300 0.75 level
	2 No	10	7	
Dressing	1 Yes	21	18	CS = 0
	2 No	0	0	
Cooking	1 Yes	18	15	CS = 0.042 0.9 level
	2 No	3	3	
Hoovering/ Dusting	1 Yes	14	13	CS = 0.140 0.75 level
	2 No	7	5	
Assistance in house	1 Yes	6	3	CS = 0.774 0.5 level
	2 No	15	15	
Confined to Chair	1 Yes	0	0	CS = 0
	2 No	21	18	

**CONTROL GROUP - CHANGE IN RATING SCORES FOR INDIVIDUAL  
QUESTIONS FOR MALE SUBGROUP**

Question	Scale	Number of Subjects at the Preoperative Interview	Number of Subjects at the Postoperative Interview	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 5 3 11	4 1 6 1 7 0 0	Chisquare = 26.333 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 4 4 4 0 7	3 0 4 0 2 0 9	Chisquare = 7.895 Significant at the 0.1 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	2 0 4 2 7 0 4 0 0	3 0 6 0 4 1 3 0 0	Chisquare = 4.464 Significant at the 0.5 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	1 0 2 1 9 0 6	3 0 8 1 5 0 2	Chisquare = 7.743 Significant at the 0.25 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	10 0 9 0 0 0 0	13 0 5 0 1 0 0	Chisquare = 2.534 Significant at the 0.5 level

Interference With Sports	1 None	0	1	Chisquare = 4.200 Significant at the 0.5 level
	2 None-Slight	0	0	
	3 Slight	0	2	
	4 Slight-Severe	1	2	
	5 Severe	6	5	
	6 Severe-Compl	0	0	
	7 Complete	12	8	
Interference With Sleep	1 None	1	11	Chisquare = 16.833 Significant at the 0.005 level
	2 None-Slight	0	0	
	3 Slight	7	7	
	4 Slight-Severe	2	0	
	5 Severe	7	1	
	6 Severe-Compl	0	0	
	7 Complete	2	0	
Walking	1 Long Distances	0	6	Chisquare = 13.143 Significant at the 0.005 level
	2 Long - Short	0	0	
	3 Short Distances	5	9	
	4 Short - House	4	2	
	5 Confined House	10	2	
Sleep on Side	1 Yes	7	17	CS = 11.310 l.t. 0.001 level
	2 No	12	2	
Driving/Transport	1 Yes	9	14	CS = 3.634 0.1 level
	2 No	10	4	
Bending Knees	1 Yes	6	15	CS = 10.087 0.005 level
	2 No	13	3	
Stairs	1 Yes	2	15	CS = 19.729 l.t. 0.001 level
	2 No	17	3	
Shopping	1 Yes	12	13	CS = 0.749 0.5 level
	2 No	7	4	
Chair Without Discomfort	1 Yes	3	16	CS = 17.789 l.t. 0.001 level
	2 No	16	3	
Bath/Shower	1 Yes	12	15	CS = 1.152 0.5 level
	2 No	7	4	
Dressing	1 Yes	18	19	CS = 1.027 0.5 level
	2 No	1	0	
Cooking	1 Yes	19	18	CS = 1.027 0.5 level
	2 No	0	1	
Hoovering/Dusting	1 Yes	15	15	CS = 0.116 0.75 level
	2 No	4	3	
Assistance in house	1 Yes	8	5	CS = 1.052 0.5 level
	2 No	11	14	
Confined to Chair	1 Yes	0	0	CS = 0
	2 No	19	19	

**CONTROL GROUP - CHANGE IN RATING SCORES FOR INDIVIDUAL  
QUESTIONS FOR FEMALE SUBGROUP**

Question	Scale	Number of Subjects at the Preoperative Interview	Number of Subjects at the Postoperative Interview	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 6 4 15	4 1 12 0 3 0 1	Chisquare = 34.160 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 1 0 4 1 19	2 0 2 2 2 0 13	Chisquare = 6.829 Significant at the 0.25 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	0 0 1 2 9 1 12 0 0	2 0 5 1 7 1 3 2 0	Chisquare = 12.397 Significant at the 0.1 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	1 0 7 0 8 1 7	8 0 9 0 3 0 1	Chisquare = 13.326 Significant at the 0.01 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	13 0 8 0 4 0 0	11 1 7 0 1 0 0	Chisquare = 2.508 Significant at the 0.5 level

Interference With Sports	1 None	0	1	Chisquare = 5.508 Significant at the 0.25 level
	2 None-Slight	0	0	
	3 Slight	0	2	
	4 Slight-Severe	0	0	
	5 Severe	3	5	
	6 Severe-Compl	0	0	
	7 Complete	22	13	
Interference With Sleep	1 None	3	14	Chisquare = 21.330 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	5	6	
	4 Slight-Severe	2	0	
	5 Severe	12	1	
	6 Severe-Compl	1	0	
	7 Complete	2	0	
Walking	1 Long Distances	0	5	Chisquare = 22.201 Significant at less than the 0.001 level
	2 Long - Short	0	1	
	3 Short Distances	4	8	
	4 Short - House	2	5	
	5 Confined House	19	2	
Sleep on Side	1 Yes	8	12	CS = 2.936 0.1 level
	2 No	17	9	
Driving/Transport	1 Yes	3	13	CS = 12.530 l.t. 0.001 level
	2 No	22	8	
Bending Knees	1 Yes	6	18	CS = 17.420 l.t. 0.001 level
	2 No	19	3	
Stairs	1 Yes	1	17	CS = 28.375 l.t. 0.001 level
	2 No	24	4	
Shopping	1 Yes	5	16	CS = 14.524 l.t. 0.001 level
	2 No	20	5	
Chair Without Discomfort	1 Yes	3	13	CS = 12.530 l.t. 0.001 level
	2 No	22	8	
Bath/Shower	1 Yes	16	14	CS = 0.036 0.9 level
	2 No	9	7	
Dressing	1 Yes	25	21	CS = 0
	2 No	0	0	
Cooking	1 Yes	22	19	CS = 0.072 0.9 level
	2 No	3	2	
Hoovering/Dusting	1 Yes	13	17	CS = 4.217 0.05 level
	2 No	12	4	
Assistance in house	1 Yes	8	4	CS = 0.993 0.5 level
	2 No	17	17	
Confined to Chair	1 Yes	1	0	CS = 0.859 0.5 level
	2 No	24	21	

CHARACTERISTICS AND ROSSER-KIND ESTIMATES OF RETROSPECTIVE GROUP PATIENTS

Number	Sex	Age (at Operation)	Operation Site	Retro-spective Period	Subject's Present RK Estimate (Rating)	My Present RK Estimate (Rating)	Subject's Retro-spective Preop RK Estimate (Rating)	My Retro-spective Preop RK Estimate (Rating)
1	F	76	Knee	1 year	IIIA (0.98)	IIIA-B (0.976)	IIID (0.912)	IIID (0.912)
2	F	89	Hip	1 year	VID (0)	VID (0)	VID (0)	VID (0)
3	M	70	Hip	2 years	IA (1)	IA (1)	II-III C (0.9645)	III-IV C (0.949)
4	M	43	Hip	1 year	IIA (0.99)	IIIA (0.98)	IVD (0.87)	IVD (0.87)
5	M	84	Hip	2 years	IVB (0.956)	IV-VB (0.9455)	VD (0.7)	VD (0.7)
6	F	64	Knee	1 year	IA (1)	IIA-B (0.988)	VD (0.7)	VD (0.7)
7	M	71	Hip	1 year	IA-B (0.9975)	IA-B (0.9975)	IIID (0.932)	IIID (0.932)
8	F	72	Hip	2 years	IIIA-B (0.976)	IIIA-B (0.976)	IIID (0.912)	IVD (0.87)
9	F	68	Knee	3 months	VC (0.9)	VD (0.7)	VD (0.7)	IVD (0.87)
10	M	61	Hip	3 months	IVB (0.956)	III-IV C (0.949)	IIID (0.912)	IVD (0.87)
11	F	68	Hip	2 years	IIA-B (0.988)	IIIA-B (0.976)	IVD (0.87)	IV-VD (0.785)

12	F	52	Hip	2 years	IA (1)	IIA (0.99)	IVD (0.87)	IV-VD (0.785)
13	F	47	Knee	1 year	IIA (0.99)	IIIA-B (0.976)	IVD (0.87)	IV-VD (0.785)
14	F	81	Hip	1 year	IIIB (0.972)	IIIB (0.972)	IIID (0.912)	IIID (0.912)
15	F	82	Hip	1 year	IIIA (0.98)	IIIA (0.98)	IVD (0.87)	IV-VD (0.785)
16	F	82	Hip	1 year	III-IVA (0.972)	IV-VA (0.955)	VD (0.7)	VD (0.7)
17	F	63	Knee	1 year	IVB (0.956)	IVB (0.956)	VD (0.7)	VD (0.7)
18	M	59	Knee	1 year	VB (0.935)	IV-VD (0.785)	VD (0.7)	IV-VD (0.785)
19	F	56	Hip	2 years	IIIA (0.98)	IIIA-B (0.976)	IVC-D (0.906)	IVC-D (0.906)
20	F	67	Hip	1 year	IIIA (0.98)	IIIA-B (0.976)	IIID (0.912)	IVD (0.87)
21	F	69	Knee	1 year	IVA-C (0.954)	IVA-C (0.954)	IVD (0.87)	IVD (0.87)
22	M	51	Hip	3 months	IIIB (0.972)	IIIB (0.972)	VD (0.7)	III-IVD (0.891)
23	F	58	Knee	1 year	IV-VA (0.955)	VA (0.946)	VID (0)	VID (0)
24	F	57	Hip	1 year	II-III A (0.985)	III-IVA (0.972)	III-IVB (0.964)	III-IVC (0.949)
25	F	58	Knee	1 year	IIIA (0.98)	IIIA (0.98)	VID (0)	VID (0)
26	F	73	Knee	1 year	VA (0.946)	VA (0.946)	VID (0)	VID (0)

27	F	82	Knee	3 months	IIIA-B (0.976)	IIIA-B (0.976)	IVD (0.87)	IV-VD (0.785)
28	F	52	Hip	3 months	VB-C (0.9175)	V-VIB-C (0.84)	VID (0)	VID (0)
29	F	78	Hip	2 years	IVA-B (0.96)	IVA-B (0.96)	VD (0.7)	VD (0.7)
30	F	78	Knee	1 year	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
31	F	41	Hip	1 year	IIIB (0.972)	III-IVB (0.964)	III-IVD (0.891)	IVD (0.87)
32	F	51	Knee	3 months	IVC (0.942)	IV-VC (0.921)	VD (0.7)	VD (0.7)
33	F	73	Hip	3 months	IVA (0.964)	IVA (0.964)	VD (0.7)	VD (0.7)
34	M	78	Hip	3 months	III-IVA (0.972)	III-IVA-B (0.968)	IVD (0.87)	IVD (0.87)
35	M	68	Hip	2 years	IVA (0.964)	IVA (0.964)	VD (0.7)	VD (0.7)
36	F	65	Hip	1 year	IV-VA (0.955)	IV-VA (0.955)	VD (0.7)	VD (0.7)
37	F	72	Hip	3 months	IV-VA-B (0.95025)	VA-B (0.9405)	VD (0.7)	VD (0.7)
38	M	57	Hip	2 years	IIIA (0.98)	IIIA (0.98)	IVD (0.87)	IV-VD (0.785)
39	F	75	Hip	1 year	IVB (0.956)	IVB (0.956)	VD (0.7)	VD (0.7)
40	F	80	Hip	3 months	VB (0.935)	VC (0.9)	VD (0.7)	VD (0.7)
41	F	68	Knee	3 months	IIIA-B (0.976)	IIIA-B (0.976)	IIID (0.912)	IIID (0.912)



42	F	78	Knee	3 months	IV-VC (0.921)	IV-VC (0.921)	IV-VD (0.785)	IV-VD (0.785)
43	M	76	Hip	2 years	IVB (0.956)	IVB (0.956)	IV-VD (0.785)	IV-VD (0.785)
44	F	74	Hip	1 year	IVB (0.956)	IVB (0.956)	IIIB (0.972)	IIIB (0.972)
45	F	68	Hip	3 months	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
46	F	65	Hip	2 years	IIA (0.99)	II-III A (0.985)	IIID (0.912)	IVD (0.87)
47	F	78	Hip	3 months	IIIA-B (0.976)	IIIA-B (0.976)	IIID (0.912)	IIID (0.912)
48	F	78	Hip	2 years	III-IVB (0.964)	III-IVB (0.964)	III-IVD (0.891)	III-IVD (0.891)
49	F	66	Hip	1 year	VD (0.7)	VD (0.7)	VD (0.7)	VD (0.7)
50	F	66	Hip	2 years	III-IVB (0.964)	III-IVC-D (0.92)	III-IVD (0.891)	III-IVD (0.891)
51	F	57	Knee	1 year	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
52	F	85	Hip	3 months	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
53	M	61	Hip	3 months	VA (0.946)	IV-VA (0.955)	VID (0)	VID (0)
54	F	55	Knee	1 year	IIIA-B (0.976)	IIIA-B (0.976)	III-IVD (0.891)	IVD (0.87)
55	M	47	Hip	2 years	IA (1)	IA (1)	IVD (0.87)	IVD (0.87)
56	F	57	Hip	3 months	IVB (0.956)	IV-VB (0.9455)	VID (0)	VID (0)

57	F	47	Hip	1 year	IIIB (0.972)	IIIB (0.972)	IVD (0.87)	IVD (0.87)
58	F	60	Hip	1 year	IIIA (0.98)	IIIA-B (0.976)	VIID (-1.486)	VIID (-1.486)
59	F	57	Hip	1 year	IVA (0.964)	IVA-B (0.96)	VD (0.7)	VD (0.7)
60	F	68	Knee	1 year	IVA (0.964)	IVA-B (0.96)	VD (0.7)	VD (0.7)
61	F	60	Hip	2 years	IA (1)	IIA (0.99)	IIIC-D (0.934)	IIIC (0.956)
62	M	72	Hip	2 years	IIIC (0.956)	IIIC (0.956)	IIID (0.912)	IIID (0.912)
63	F	49	Knee	1 year	IA (1)	IA (1)	IVD (0.87)	IV-VD (0.785)
64	M	69	Knee	1 year	IIA (0.99)	IIA (0.99)	IVD (0.87)	IVD (0.87)
65	M	64	Hip	1 year	IIA (0.99)	IIA-B (0.988)	III-IVD (0.891)	IIID (0.912)
66	M	74	Hip	1 year	IIA (0.99)	IIA (0.99)	VIID (-1.486)	VIID (-1.486)
67	F	62	Hip	3 months	IIIB-C (0.964)	IIIB-C (0.964)	IIIC (0.956)	IIIC (0.956)
68	M	52	Hip	1 year	II-IIIIB (0.979)	II-IIIIB (0.979)	IVD (0.87)	IV-VD (0.785)
69	F	82	Hip	3 months	VA-B (0.9405)	VB (0.935)	VID (0)	V-VID (0.35)
70	F	79	Hip	1 year	VA (0.946)	VA (0.946)	VD (0.7)	VD (0.7)
71	F	77	Hip	1 year	IVA (0.964)	IVA (0.964)	IV-VD (0.785)	IV-VD (0.785)

72	F	76	Hip	1 year	IVC (0.942)	IVC (0.942)	IVC (0.942)	IVC (0.942)
73	F	71	Hip	1 year	IVA (0.964)	IVA (0.964)	VD (0.7)	VD (0.7)
74	M	68	Hip	3 months	VB (0.935)	VB-C (0.9175)	IVD (0.87)	IVD (0.87)
75	F	75	Hip	3 months	IV-VB (0.9455)	IV-VB (0.9455)	IV-VD (0.785)	IV-VD (0.785)
76	M	75	Hip	2 years	IIIB (0.972)	IVB (0.956)	IIIC-D (0.934)	IIIC-D (0.934)
77	F	82	Knee	3 months	IV-VA (0.955)	IV-VA (0.955)	VD (0.7)	VD (0.7)
78	F	58	Hip	2 years	VA-B (0.9405)	VC (0.9)	IVD (0.87)	VD (0.7)
79	F	76	Knee	1 year	VA (0.946)	VA (0.946)	VD (0.7)	VD (0.7)
80	F	80	Knee	1 year	VA (0.946)	VA (0.946)	VB (0.935)	VB-C (0.9175)
81	M	59	Hip	2 years	IA (1)	IA (1)	IVC (0.942)	IVC (0.942)
82	M	74	Hip	2 years	IIIA (0.98)	IIIA (0.98)	IIID (0.912)	IIID (0.912)
83	M	66	Hip	2 years	IIIB (0.972)	IIIB (0.972)	VD (0.7)	VD (0.7)
84	F	30	Knee	1 year	IIA (0.99)	IIA (0.99)	III-IVD (0.891)	IVD (0.87)
85	M	66	Hip	1 year	VA (0.946)	VA (0.946)	VID (0)	VID (0)
86	F	70	Knee	1 year	IVA (0.964)	IVA (0.964)	IVD (0.87)	IVD (0.87)

87	F	60	Hip	2 years	IIIA (0.98)	IIIA (0.98)	IIIC (0.956)	IIIC (0.956)
88	M	69	Hip	2 years	IA (1)	I-IIA (0.995)	IID (0.932)	II-IIID (0.922)
89	M	59	Knee	1 year	IIA (0.99)	IVA (0.964)	IVD (0.87)	VID (0)
90	F	74	Knee	1 year	IVB (0.956)	IV-VB (0.9455)	VD (0.7)	VD (0.7)
91	F	47	Hip	1 year	IIIA (0.98)	III-IVA (0.972)	VD (0.7)	VD (0.7)
92	M	42	Hip	3 months	IVA (0.964)	III-IVA (0.972)	IVD (0.87)	IVD (0.87)
93	F	70	Hip	1 year	VA (0.946)	IV-VA (0.955)	VD (0.7)	IV-VD (0.785)
94	M	56	Hip	2 years	III-IVC (0.949)	IIIC (0.956)	III-IVD (0.891)	IVD (0.87)
95	F	66	Hip	3 months	IIIA (0.98)	IIIA (0.98)	VD (0.7)	VD (0.7)
96	F	30	Hip	3 months	IV-VA-B (0.95025)	VA-B (0.9405)	VID (0)	VID (0)
97	F	69	Knee	3 months	VC (0.9)	VC (0.9)	VC (0.9)	VC (0.9)
98	M	72	Knee	1 year	IVA (0.964)	IVA (0.964)	IVD (0.87)	IVD (0.87)
99	F	67	Hip	2 years	VB (0.935)	VB (0.935)	VD (0.7)	IV-VD (0.785)
100	F	55	Hip	2 years	VD (0.7)	VD (0.7)	VID (0)	VID (0)
101	F	72	Hip	2 years	IV-VA (0.955)	IV-VA (0.955)	VD (0.7)	VD (0.7)

102	M	68	Hip	1 year	IVA-B (0.96)	IVA-B (0.96)	IVD (0.87)	IVD (0.87)
103	F	56	Knee	1 year	III-IVA (0.972)	III-IVA (0.972)	VD (0.7)	VD (0.7)
104	F	63	Knee	1 year	IVA-B (0.96)	IVA-B (0.96)	IVC-D (0.906)	IVC (0.942)
105	F	81	Hip	2 years	IVA (0.964)	IVA (0.964)	IVD (0.87)	IVD (0.87)
106	F	69	Knee	1 year	IIA-B (0.988)	IIA-B (0.988)	IVD (0.87)	IVD (0.87)
107	M	48	Hip	2 years	IIIB (0.972)	IIIB (0.972)	VID (0)	VID (0)
108	M	72	Knee	1 year	IIIA-B (0.976)	IIIA-B (0.976)	IID (0.912)	IID (0.912)
109	F	55	Hip	1 year	IIA-B (0.988)	IIA-B (0.988)	IID (0.912)	IID (0.912)
110	F	71	Hip	1 year	VA (0.946)	VA (0.946)	V-VID (0.35)	V-VID (0.35)
111	M	69	Hip	1 year	IIIA-B (0.976)	IIIA-B (0.976)	IID (0.912)	IID (0.912)
112	F	74	Knee	3 months	VD (0.7)	VD (0.7)	IVD (0.87)	IVD (0.87)
113	M	68	Hip	2 years	IIIB (0.972)	IIIB (0.972)	IVD (0.87)	IVD (0.87)
114	M	62	Hip	2 years	IIA (0.99)	IVA (0.964)	IVD (0.87)	IVD (0.87)
115	F	74	Knee	1 year	IVA-B (0.96)	IV-VA-B (0.95025)	IVD (0.87)	IV-VD (0.785)
116	F	68	Hip	1 year	IVB (0.956)	IVB (0.956)	VD (0.7)	VD (0.7)

117	F	68	Knee	1 year	IIIB (0.972)	IIIB (0.972)	IVD (0.87)	IVD (0.87)
118	F	64	Hip	1 year	IVB (0.956)	IVB (0.956)	IVD (0.87)	IVD (0.87)
119	F	75	Hip	1 year	VA (0.946)	VA (0.946)	VD (0.7)	VD (0.7)
120	F	77	Hip	2 years	IIIA (0.98)	IIIA (0.98)	IVC-D (0.906)	IVC-D (0.906)
121	F	74	Hip	2 years	IVA (0.964)	IVA (0.964)	IID (0.912)	IID (0.912)
122	M	78	Hip	2 years	IIIA (0.98)	IIIA (0.98)	IID (0.912)	IID (0.912)
123	F	76	Hip	2 years	VA (0.946)	VA (0.946)	VD (0.7)	VD (0.7)
124	F	69	Knee	1 year	IVB (0.956)	IVB (0.956)	IVD (0.87)	IV-VD (0.785)
125	M	68	Knee	1 year	IA (1)	IIA-B (0.988)	IIIC (0.956)	IIIC (0.973)
126	F	82	Hip	2 years	VC (0.9)	VC (0.9)	VD (0.7)	IV-VD (0.785)
127	M	58	Hip	2 years	VA (0.946)	IV-VA (0.955)	VD (0.7)	IV-VD (0.785)
128	F	59	Hip	2 years	II-IIIB (0.979)	IIIB (0.972)	VD (0.7)	VD (0.7)
129	F	51	Hip	2 years	IIA (0.990)	IIIA (0.98)	IVD (0.87)	IVD (0.87)
130	F	51	Knee	3 months	VB (0.935)	VB (0.935)	VD (0.7)	VD (0.7)
131	F	78	Knee	3 months	IVB (0.956)	IVB (0.956)	IV-VD (0.785)	IV-VD (0.785)

132	M	75	Hip	1 year	IIIA (0.98)	IIIA (0.98)	IVB (0.956)	IVB (0.956)
133	M	68	Hip	1 year	IIA (0.99)	IIA (0.99)	IID (0.932)	IID (0.912)
134	M	70	Hip	2 years	IIA (0.99)	IIA (0.99)	II-IIIB-C (0.97175)	II-IIIB-C (0.97175)
135	F	52	Knee	1 year	IVC (0.942)	IV-VC (0.921)	VD (0.7)	VD (0.7)
136	F	73	Hip	2 years	IVC (0.942)	IVB-C (0.949)	VD (0.7)	VD (0.7)
137	F	53	Hip	2 years	IIA (0.99)	IIIA (0.98)	VD (0.7)	VD (0.7)
138	M	72	Hip	3 months	IVC (0.942)	IVC (0.942)	IIIC-D (0.934)	IIIC-D (0.934)
139	M	68	Hip	2 years	IA (1)	IA (1)	IID (0.912)	IVD (0.87)
140	F	62	Hip	2 years	IIIA (0.98)	IIIA (0.98)	VD (0.7)	VD (0.7)
141	M	77	Hip	2 years	III-IVA (0.972)	III-IVA (0.972)	IVD (0.87)	IVD (0.87)
142	M	52	Hip	2 years	IV-VB (0.9455)	IV-VB (0.9455)	VD (0.7)	VD (0.7)
143	M	80	Hip	1 year	IIIA (0.98)	IIIA (0.98)	IID (0.912)	IID (0.912)
144	F	59	Knee	1 year	IVC (0.942)	IVC (0.942)	IID (0.912)	II-IIID (0.922)
145	M	62	Hip	2 years	VA-B (0.9405)	IVA-B (0.96)	IVD (0.87)	IV-VD (0.785)
146	F	80	Knee	1 year	IVB (0.956)	IVB (0.956)	IVC (0.942)	IVC (0.942)

147	M	66	Hip	2 years	III C (0.956)	III C (0.956)	III D (0.912)	III D (0.912)
148	M	57	Hip	1 year	II-III B-C (0.97175)	II-III B-C (0.97175)	IV D (0.87)	IV-VD (0.785)
149	F	63	Hip	2 years	-	IV B (0.956)	-	IV C (0.942)
150	F	67	Hip	2 years	-	III C (0.956)	-	IV-VD (0.785)
151	M	66	Hip	2 years	-	I-II A (0.995)	-	IV D (0.87)
152	F	48	Hip	1 year	-	VI C (0.68)	-	VID (0)
153	F	67	Hip	2 years	-	III A-B (0.976)	-	IV C (0.942)
154	F	70	Hip	2 years	-	III A (0.98)	-	VD (0.7)
155	F	70	Hip	2 years	-	VB (0.935)	-	IV-VD (0.785)
156	F	57	Hip	2 years	-	II-III A (0.985)	-	VD (0.7)
157	F	57	Hip	2 years	-	VD (0.7)	-	V-VID (0.35)
158	M	69	Hip	2 years	-	IA (1)	-	IV D (0.87)
159	F	70	Hip	2 years	-	VC (0.9)	-	VD (0.7)



**RETROSPECTIVE GROUP - CHANGE IN RATING SCORES FOR  
INDIVIDUAL QUESTIONS FOR THREE MONTH HIP SUBGROUP**

Question	Scale	Number of Subjects at the Retrospective Stage	Number of Subjects at the Postoperative Stage	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 0 1 1 18	4 1 9 2 4 0 0	Chisquare = 36.8 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 1 0 4 0 15	0 0 2 0 2 0 16	Chisquare = 1.032 Significant at the 0.75 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	0 0 4 0 3 2 6 0 5	1 0 5 1 4 1 8 0 0	Chisquare = 7.873 Significant at the 0.25 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	3 0 3 0 5 0 9	6 0 7 2 3 0 2	Chisquare = 9.555 Significant at the 0.05 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	8 0 6 0 6 0 0	15 0 4 0 1 0 0	Chisquare = 6.102 Significant at the 0.05 level

Interference With Sports	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	0 0 0 0 0 0 20	0 0 2 1 4 0 13	Chisquare = 8.485 Significant at the 0.05 level
Interference With Sleep	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	2 0 3 3 9 0 3	9 0 8 1 2 0 0	Chisquare = 15.182 Significant at the 0.005 level
Walking	1 Long Distances 2 Long - Short 3 Short Distances 4 Short - House 5 Confined House	2 0 1 1 16	2 0 6 6 6	Chisquare = 11.688 Significant at the 0.01 level
Sleep on Side	1 Yes 2 No	3 17	9 10	CS = 4.792 0.05 level
Driving/ Transport	1 Yes 2 No	6 14	10 10	CS = 1.667 0.25 level
Bending Knees	1 Yes 2 No	7 13	14 6	CS = 4.912 0.05 level
Stairs	1 Yes 2 No	3 17	13 7	CS = 10.417 0.005 level
Shopping	1 Yes 2 No	9 11	10 10	CS = 0.1 0.9 level
Chair Without Discomfort	1 Yes 2 No	2 18	16 4	CS = 19.798 l.t. 0.001 level
Bath/ Shower	1 Yes 2 No	12 8	12 8	CS = 0
Dressing	1 Yes 2 No	18 2	19 1	CS = 0.36 0.75 level
Cooking	1 Yes 2 No	15 5	18 2	CS = 1.558 0.25 level
Hoovering/ Dusting	1 Yes 2 No	9 11	12 8	CS = 0.902 0.5 level
Assistance in house	1 Yes 2 No	8 12	8 12	CS = 0
Confined to Chair	1 Yes 2 No	5 15	1 19	CS = 3.137 0.1 level

**RETROSPECTIVE GROUP - CHANGE IN RATING SCORES FOR  
INDIVIDUAL QUESTIONS FOR ONE YEAR HIP SUBGROUP**

Question	Scale	Number of Subjects at the Retrospective Stage	Number of Subjects at the Postoperative Stage	Chisquare Test (CS)
Pain	1 None	0	17	Chisquare = 57.675 Significant at less than the 0.001 level
	2 None-Slight	0	3	
	3 Slight	2	11	
	4 Slight-Moderate	0	3	
	5 Moderate	2	2	
	6 Moder-Severe	0	0	
	7 Severe	34	2	
Impairment of Work	1 None	2	3	Chisquare = 6.809 Significant at the 0.25 level
	2 None-Slight	0	0	
	3 Slight	1	7	
	4 Slight-Severe	1	0	
	5 Severe	4	2	
	6 Severe-Compl	0	0	
	7 Complete	30	25	
Housework	1 All	2	8	Chisquare = 10.044 Significant at the 0.25 level
	2 All - All-Heavy	0	0	
	3 All but Heavy	8	10	
	4 All-Heavy-Light	0	1	
	5 Light	8	10	
	6 Light - Few	1	1	
	7 Few Tasks	14	7	
	8 Few - None	0	0	
	9 None	5	1	
Interference With Hobbies	1 None	2	18	Chisquare = 22.563 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	14	14	
	4 Slight-Severe	1	0	
	5 Severe	14	5	
	6 Severe-Compl	0	0	
	7 Complete	7	1	
Dependence On Others	1 None	17	29	Chisquare = 8.464 Significant at the 0.05 level
	2 None-Occasion	0	0	
	3 Occasional	14	7	
	4 Occasional-Reg	0	0	
	5 Regular	6	2	
	6 Regular - Total	0	0	
	7 Total	1	0	

Interference With Sports	1 None	0	2	Chisquare = 15.079 Significant at the 0.005 level
	2 None-Slight	0	0	
	3 Slight	0	5	
	4 Slight-Severe	0	1	
	5 Severe	3	9	
	6 Severe-Compl	0	0	
	7 Complete	35	20	
Interference With Sleep	1 None	7	26	Chisquare = 27.834 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	9	10	
	4 Slight-Severe	4	0	
	5 Severe	17	2	
	6 Severe-Compl	0	0	
	7 Complete	1	0	
Walking	1 Long Distances	0	12	Chisquare = 48.923 Significant at less than the 0.001 level
	2 Long - Short	0	4	
	3 Short Distances	3	16	
	4 Short - House	3	3	
	5 Confined House	32	3	
Sleep on Side	1 Yes	13	26	CS = 8.901 0.005 level
	2 No	25	12	
Driving/ Transport	1 Yes	12	31	CS = 19.335 l.t. 0.001 level
	2 No	26	7	
Bending Knees	1 Yes	14	32	CS = 17.843 l.t. 0.001 level
	2 No	24	6	
Stairs	1 Yes	5	33	CS = 41.263 l.t. 0.001 level
	2 No	33	5	
Shopping	1 Yes	18	29	CS = 6.747 0.01 level
	2 No	20	9	
Chair Without Discomfort	1 Yes	7	33	CS = 35.678 l.t. 0.001 level
	2 No	31	5	
Bath/ Shower	1 Yes	20	30	CS = 5.846 0.025 level
	2 No	18	8	
Dressing	1 Yes	35	38	CS = 3.123 0.1 level
	2 No	3	0	
Cooking	1 Yes	30	37	CS = 6.176 0.025 level
	2 No	8	1	
Hoovering/ Dusting	1 Yes	20	29	CS = 4.653 0.05 level
	2 No	18	9	
Assistance in house	1 Yes	16	7	CS = 5.050 0.025 level
	2 No	22	31	
Confined to Chair	1 Yes	3	1	CS = 1.056 0.5 level
	2 No	35	37	

**RETROSPECTIVE GROUP - CHANGE IN RATING SCORES FOR  
INDIVIDUAL QUESTIONS FOR TWO YEAR HIP SUBGROUP**

Question	Scale	Number of Subjects at the Retrospective Stage	Number of Subjects at the Postoperative Stage	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 1 6 3 48	29 1 15 3 7 1 2	Chisquare = 89.397 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	1 0 6 1 11 0 35	13 0 9 1 1 1 30	Chisquare = 20.596 Significant at less than the 0.001 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	2 0 13 2 20 1 17 0 2	14 0 20 3 12 0 8 0 0	Chisquare = 18.925 Significant at the 0.005 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	11 0 14 1 18 0 13	34 0 18 0 2 0 3	Chisquare = 32.306 Significant at less than the 0.001 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	31 0 20 0 6 0 1	46 2 8 0 2 0 0	Chisquare = 13.065 Significant at the 0.025 level

Interference With Sports	1 None	0	4	Chisquare = 18.168 Significant at the 0.005 level
	2 None-Slight	0	1	
	3 Slight	1	11	
	4 Slight-Severe	1	1	
	5 Severe	7	10	
	6 Severe-Compl	0	0	
	7 Complete	42	25	
Interference With Sleep	1 None	2	43	Chisquare = 72.132 Significant at less than the 0.001 level
	2 None-Slight	0	1	
	3 Slight	15	11	
	4 Slight-Severe	8	0	
	5 Severe	28	3	
	6 Severe-Compl	0	0	
	7 Complete	5	0	
Walking	1 Long Distances	0	26	Chisquare = 68.681 Significant at less than the 0.001 level
	2 Long - Short	1	1	
	3 Short Distances	8	23	
	4 Short - House	3	4	
	5 Confined House	46	4	
Sleep on Side	1 Yes	13	50	CS = 47.560 l.t. 0.001 level
	2 No	45	8	
Driving/ Transport	1 Yes	21	47	CS = 26.958 l.t. 0.001 level
	2 No	37	9	
Bending Knees	1 Yes	31	51	CS = 18.234 l.t. 0.001 level
	2 No	27	6	
Stairs	1 Yes	7	47	CS = 57.183 l.t. 0.001 level
	2 No	51	10	
Shopping	1 Yes	26	46	CS = 15.079 l.t. 0.001 level
	2 No	31	11	
Chair Without Discomfort	1 Yes	8	46	CS = 50.031 l.t. 0.001 level
	2 No	50	12	
Bath/ Shower	1 Yes	40	47	CS = 2.253 0.25 level
	2 No	18	11	
Dressing	1 Yes	54	58	CS = 4.143 0.05 level
	2 No	4	0	
Cooking	1 Yes	53	56	CS = 1.883 0.25 level
	2 No	4	1	
Hoovering/ Dusting	1 Yes	34	48	CS = 8.515 0.005 level
	2 No	23	9	
Assistance in house	1 Yes	16	11	CS = 1.213 0.5 level
	2 No	41	46	
Confined to Chair	1 Yes	2	0	CS = 2.036 0.25 level
	2 No	55	57	

**RETROSPECTIVE GROUP - CHANGE IN RATING SCORES FOR  
INDIVIDUAL QUESTIONS FOR THREE MONTH KNEE SUBGROUP**

Question	Scale	Number of Subjects at the Retrospective Stage	Number of Subjects at the Postoperative Stage	Chisquare Test (CS)
Pain	1 None	0	1	Chisquare = 10.455 Significant at the 0.05 level
	2 None-Slight	0	1	
	3 Slight	0	3	
	4 Slight-Moderate	0	0	
	5 Moderate	1	3	
	6 Moder-Severe	0	0	
	7 Severe	9	2	
Impairment of Work	1 None	0	0	Chisquare = 2.0 Significant at the 0.5 level
	2 None-Slight	0	0	
	3 Slight	0	1	
	4 Slight-Severe	1	0	
	5 Severe	0	0	
	6 Severe-Compl	0	0	
	7 Complete	9	9	
Housework	1 All	0	0	Chisquare = 0
	2 All - All-Heavy	0	0	
	3 All but Heavy	2	2	
	4 All-Heavy-Light	0	0	
	5 Light	4	4	
	6 Light - Few	0	0	
	7 Few Tasks	4	4	
	8 Few - None	0	0	
	9 None	0	0	
Interference With Hobbies	1 None	3	4	Chisquare = 2.254 Significant at the 0.75 level
	2 None-Slight	0	0	
	3 Slight	5	4	
	4 Slight-Severe	0	0	
	5 Severe	1	0	
	6 Severe-Compl	0	0	
	7 Complete	0	1	
Dependence On Others	1 None	6	5	Chisquare = 2.232 Significant at the 0.75 level
	2 None-Occasion	0	1	
	3 Occasional	3	4	
	4 Occasional-Reg	0	0	
	5 Regular	1	0	
	6 Regular - Total	0	0	
	7 Total	0	0	

Interference With Sports	1 None	0	0	Chisquare = 2.222 Significant at the 0.25 level
	2 None-Slight	0	0	
	3 Slight	0	2	
	4 Slight-Severe	0	0	
	5 Severe	0	0	
	6 Severe-Compl	0	0	
	7 Complete	10	8	
Interference With Sleep	1 None	0	5	Chisquare = 13.143 Significant at the 0.025 level
	2 None-Slight	0	0	
	3 Slight	3	4	
	4 Slight-Severe	1	0	
	5 Severe	6	0	
	6 Severe-Compl	0	0	
	7 Complete	0	1	
Walking	1 Long Distances	0	1	Chisquare = 13.333 Significant at the 0.005 level
	2 Long - Short	0	0	
	3 Short Distances	0	3	
	4 Short - House	0	4	
	5 Confined House	10	2	
Sleep on Side	1 Yes	6	7	CS = 0.220 0.75 level
	2 No	4	3	
Driving/ Transport	1 Yes	0	2	CS = 2.222 0.25 level
	2 No	10	8	
Bending Knees	1 Yes	0	7	CS = 10.769 0.005 level
	2 No	10	3	
Stairs	1 Yes	0	6	CS = 8.571 0.005 level
	2 No	10	4	
Shopping	1 Yes	3	3	CS = 0
	2 No	7	7	
Chair Without Discomfort	1 Yes	1	7	CS = 7.5 0.01 level
	2 No	9	3	
Bath/ Shower	1 Yes	7	8	CS = 0.267 0.75 level
	2 No	3	2	
Dressing	1 Yes	9	9	CS = 0
	2 No	1	1	
Cooking	1 Yes	8	10	CS = 2.222 0.25 level
	2 No	2	0	
Hoovering/ Dusting	1 Yes	4	5	CS = 0.202 0.75 level
	2 No	6	5	
Assistance in house	1 Yes	3	3	CS = 0
	2 No	7	7	
Confined to Chair	1 Yes	0	0	CS = 0
	2 No	10	10	



**RETROSPECTIVE GROUP - CHANGE IN RATING SCORES FOR  
INDIVIDUAL QUESTIONS FOR ONE YEAR KNEE SUBGROUP**

Question	Scale	Number of Subjects at the Retrospective Stage	Number of Subjects at the Postoperative Stage	Chisquare Test (CS)
Pain	1 None 2 None-Slight 3 Slight 4 Slight-Moderate 5 Moderate 6 Moder-Severe 7 Severe	0 0 0 1 3 0 28	13 0 15 1 2 0 1	Chisquare = 53.338 Significant at less than the 0.001 level
Impairment of Work	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	2 0 1 1 4 0 24	6 0 6 0 2 0 18	Chisquare = 8.095 Significant at the 0.1 level
Housework	1 All 2 All - All-Heavy 3 All but Heavy 4 All-Heavy-Light 5 Light 6 Light - Few 7 Few Tasks 8 Few - None 9 None	1 0 4 0 13 0 10 0 4	4 0 8 1 13 0 6 0 0	Chisquare = 9.133 Significant at the 0.25 level
Interference With Hobbies	1 None 2 None-Slight 3 Slight 4 Slight-Severe 5 Severe 6 Severe-Compl 7 Complete	7 0 2 0 14 0 8	16 0 11 0 3 0 2	Chisquare = 20.459 Significant at less than the 0.001 level
Dependence On Others	1 None 2 None-Occasion 3 Occasional 4 Occasional-Reg 5 Regular 6 Regular - Total 7 Total	17 0 8 0 7 0 0	28 0 4 0 0 0 0	Chisquare = 11.022 Significant at the 0.005 level

Interference With Sports	1 None	0	1	Chisquare = 11.478 Significant at the 0.025 level
	2 None-Slight	0	0	
	3 Slight	1	9	
	4 Slight-Severe	0	1	
	5 Severe	2	2	
	6 Severe-Compl	0	0	
	7 Complete	29	17	
Interference With Sleep	1 None	4	22	Chisquare = 29.795 Significant at less than the 0.001 level
	2 None-Slight	0	0	
	3 Slight	9	9	
	4 Slight-Severe	2	1	
	5 Severe	14	0	
	6 Severe-Compl	0	0	
	7 Complete	3	0	
Walking	1 Long Distances	0	14	Chisquare = 29.930 Significant at less than the 0.001 level
	2 Long - Short	0	3	
	3 Short Distances	5	8	
	4 Short - House	4	2	
	5 Confined House	23	5	
Sleep on Side	1 Yes	9	28	CS = 23.127 l.t. 0.001 level
	2 No	23	4	
Driving/Transport	1 Yes	9	23	CS = 12.250 l.t. 0.001 level
	2 No	23	9	
Bending Knees	1 Yes	2	28	CS = 42.416 l.t. 0.001 level
	2 No	30	4	
Stairs	1 Yes	2	20	CS = 22.442 l.t. 0.001 level
	2 No	30	12	
Shopping	1 Yes	14	24	CS = 6.478 0.025 level
	2 No	18	8	
Chair Without Discomfort	1 Yes	6	25	CS = 22.585 l.t. 0.001 level
	2 No	26	7	
Bath/Shower	1 Yes	20	27	CS = 3.925 0.05 level
	2 No	12	5	
Dressing	1 Yes	29	32	CS = 3.148 0.1 level
	2 No	3	0	
Cooking	1 Yes	27	31	CS = 2.943 0.1 level
	2 No	5	1	
Hoovering/Dusting	1 Yes	19	25	CS = 2.618 0.25 level
	2 No	13	7	
Assistance in house	1 Yes	11	5	CS = 3.0 0.1 level
	2 No	21	27	
Confined to Chair	1 Yes	4	0	CS = 4.267 0.05 level
	2 No	28	32	

**HIP PATIENTS MATCHED BETWEEN CONTROL AND  
RETROSPECTIVE GROUPS IN TERMS OF AGE AND SEX**

Control Group (No / Sex / Age at Operation)	Matched Three Months Retrospective Group (No / Sex / Age at Operation)	First Matched One Year Retrospective Group (No / Sex / Age at Operation)	Second Matched One Year Retrospective Group (No /Sex / Age at Operation)	First Matched Two Year Retrospective Group (No / Sex / Age at Operation)	Second Matched Two Year Retrospective Group (No / Sex / Age at Operation)
2) F 59	56) F 57	24) F 57	*	61) F 60	78) F 58
4) M 67	*	102) M 68	*	35) M 68	151) M 66
5) F 55	28) F 52	57) F 47	152) F 48	12) F 52	100) F 55
6) M 62	10) M 61	49) F 66	*	38) M 57	145) M 62
7) M 64	*	65) M 64	*	50) F 66	114) M 62
8) F 67	45) F 68	20) F 67	*	11) F 68	99) F 67
9) F 74	33) F 73	44) F 74	110) F 71	101) F 72	121) F 74
11) F 65	67) F 62	36) F 65	*	46) F 65	153) F 67
12) M 43	92) M 42	4) M 43	68) M 52	55) M 47	107) M 48
14) F 75	47) F 78	39) F 75	119) F 75	29) F 78	120) F 77
18) F 55	22) M 51	59) F 57	109) F 55	19) F 56	129) F 51
20) M 70	*	7) M 71	73) F 71	3) M 70	159) F 70
21) M 64	*	118) F 64	*	87) F 60	147) M 66
23) M 70	37) F 72	133) M 68	*	62) M 72	134) M 70
25) M 73	138) M 72	66) M 74	72) F 76	8) F 72	82) M 74
26) F 67	95) F 66	93) F 70	116) F 68	150) F 67	154) F 70
29) F 64	*	58) F 60	*	140) F 62	149) F 63
31) M 69	74) M 68	111) M 69	*	88) M 69	113) M 68
33) M 67	*	85) M 66	*	83) M 66	139) M 68
38) F 83	40) F 80	14) F 81	15) F 82	48) F 78	105) F 81
39) M 73	75) F 75	71) F 77	132) M 75	43) M 76	76) M 75
41) M 78	34) M 78	70) F 79	143) M 80	122) M 78	141) M 77
42) M 62	53) M 61	148) M 57	*	81) M 59	127) M 58

**KNEE PATIENTS MATCHED BETWEEN CONTROL AND  
RETROSPECTIVE GROUPS IN TERMS OF AGE AND SEX**

Control Group (No / Sex / Age at Operation)	Matched Three Months Retrospective Group (No / Sex / Age at Operation)	First Matched One Year Retrospective Group (No / Sex / Age at Operation)	Second Matched One Year Retrospective Group (No / Sex / Age at Operation)
1) F 69	9) F 68	106) F 69	124) F 69
3) F 72	97) F 69	26) F 73	86) F 70
10) F 82	27) F 82	1) F 76	*
13) M 66	*	60) F 68	64) M 69
15) F 52	32) F 51	13) F 47	63) F 49
16) F 81	*	146) F 80	*
17) F 65	41) F 68	6) F 64	21) F 69
19) F 80	131) F 78	80) F 80	*
22) F 82	77) F 82	79) F 76	*
24) F 59	*	51) F 57	103) F 56
27) M 58	*	18) M 59	23) F 58
28) F 75	112) F 74	90) F 74	*
30) M 66	*	117) F 68	125) M 68
32) F 76	*	115) F 74	*
34) M 61	*	25) F 58	89) M 59
35) M 67	*	98) M 72	108) M 72
36) F 87	*	*	*
37) M 65	*	104) F 63	*
40) F 52	130) F 51	54) F 55	135) F 52
43) F 79	42) F 78	30) F 78	*
44) F 63	*	17) F 63	*

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF CAPD DATA**

Conversion of Karnofsky Index into Rosser Disability/Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
A = I-IIA	2	1.65	£23,923	£14,499
B = IIIB	4	3.16	£45,623	£14,438
C = IVC	6	4.52	£65,304	£14,448
D = V-VID	8	5.75	£83,156	£14,462
E = VII-VIID	10	6.87	£99,347	£14,461
A = I-IIA	2	1.73	£23,923	£13,828
B = III-IVA	4	3.30	£45,623	£13,825
C = VB	6	4.72	£65,304	£13,836
D = VIC	8	6.01	£83,156	£13,836
E = VII-VIID	10	7.18	£99,347	£13,837
A = I-IIA	2	1.73	£23,923	£13,828
B = III-IVB	4	3.30	£45,623	£13,825
C = VC	6	4.72	£65,304	£13,836
D = VIC	8	6.01	£83,156	£13,836
E = VII-VIID	10	7.18	£99,347	£13,837
A = I-IIA	2	1.73	£23,923	£13,828
B = IIIB	4	3.30	£45,623	£13,825
C = IV-VC	6	4.72	£65,304	£13,836
D = VIC	8	6.01	£83,156	£13,836
E = VII-VIID	10	7.18	£99,347	£13,837
A = IA	2	1.75	£23,923	£13,670
B = II-IIIB	4	3.33	£45,623	£13,701
C = IV-VB	6	4.77	£65,304	£13,691
D = VIC	8	6.08	£83,156	£13,677
E = VII-VIID	10	7.26	£99,347	£13,684
A = IA	2	1.75	£23,923	£13,670
B = II-IIIB	4	3.33	£45,623	£13,701
C = IV-VC	6	4.77	£65,304	£13,691
D = VIC	8	6.08	£83,156	£13,677
E = VII-VIID	10	7.26	£99,347	£13,684
A = I-IIA	2	1.75	£23,923	£13,670
B = IIIA	4	3.33	£45,623	£13,701
C = IV-VB	6	4.77	£65,304	£13,691
D = VIC	8	6.08	£83,156	£13,677
E = VII-VIID	10	7.26	£99,347	£13,684

A = I-IIA	2	1.77	£23,923	£13,516
B = IIIB	4	3.37	£45,623	£13,538
C = IVB	6	4.82	£65,304	£13,549
D = V-VIC	8	6.14	£83,156	£13,543
E = VII-VIIID	10	7.34	£99,347	£13,535
A = IA	2	1.79	£23,923	£13,365
B = II-IIIA	4	3.40	£45,623	£13,419
C = IVB	6	4.87	£65,304	£13,409
D = V-VIC	8	6.20	£83,156	£13,412
E = VII-VIIID	10	7.41	£99,347	£13,407
A = IA	2	1.79	£23,923	£13,365
B = II-IIIB	4	3.40	£45,623	£13,419
C = IVC	6	4.87	£65,304	£13,409
D = V-VIC	8	6.20	£83,156	£13,412
E = VII-VIIID	10	7.41	£99,347	£13,407
A = IA	2	1.80	£23,923	£13,291
B = II-IIIB	4	3.44	£45,623	£13,263
C = IVC	6	4.92	£65,304	£13,273
D = VC	8	6.27	£83,156	£13,263
E = VI-VIIID	10	7.49	£99,347	£13,264
A = I-IIA	2	1.80	£23,923	£13,291
B = IIIA	4	3.44	£45,623	£13,263
C = IVB	6	4.92	£65,304	£13,273
D = VC	8	6.27	£83,156	£13,263
E = VI-VIIID	10	7.49	£99,347	£13,264
A = I-IIA	2	1.80	£23,923	£13,291
B = IIIB	4	3.44	£45,623	£13,263
C = IVC	6	4.92	£65,304	£13,273
D = VC	8	6.27	£83,156	£13,263
E = VI-VIIID	10	7.49	£99,347	£13,264
A = IA	2	1.82	£23,923	£13,145
B = II-IIIA	4	3.48	£45,623	£13,110
C = IVB	6	4.97	£65,304	£13,140
D = VC	8	6.33	£83,156	£13,137
E = VI-VIIID	10	7.57	£99,347	£13,124

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF HAEMODIALYSIS DATA  
PROCCI (1980)**

Conversion of Social Disability Scores into Rosser Disability Categories	Conversion of Social Modifiers into Rosser Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.65 3.16 4.52 5.75 6.87	£15,933 £30,386 £43,494 £55,383 £66,167	£9,656 £9,616 £9,623 £9,632 £9,631
0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.67 3.19 4.57 5.82 6.95	£15,933 £30,386 £43,494 £55,383 £66,167	£9,541 £9,525 £9,517 £9,516 £9,520
0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.67 3.19 4.57 5.82 6.95	£15,933 £30,386 £43,494 £55,383 £66,167	£9,541 £9,525 £9,517 £9,516 £9,520
0-20 = I 20-49 = II 50-59 = III 60-69 = IV 70-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.67 3.19 4.57 5.82 6.95	£15,933 £30,386 £43,494 £55,383 £66,167	£9,541 £9,525 £9,517 £9,516 £9,520

0-20 = I	1-9 = A	2	1.67	£15,933	£9,541
20-49 = II	10-19 = B	4	3.19	£30,386	£9,525
50-59 = III	20-39 = C	6	4.57	£43,494	£9,517
60-69 = IV	40-55 = D	8	5.82	£55,383	£9,516
70-74 = V		10	6.95	£66,167	£9,520
75-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.67	£15,933	£9,541
20-49 = II	10-24 = B	4	3.19	£30,386	£9,525
50-59 = III	25-39 = C	6	4.57	£43,494	£9,517
60-69 = IV	40-55 = D	8	5.82	£55,383	£9,516
70-74 = V		10	6.95	£66,167	£9,520
75-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.75	£15,933	£9,105
20-39 = II	6-19 = B	4	3.33	£30,386	£9,125
40-59 = III	20-39 = C	6	4.77	£43,494	£9,118
60-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-39 = II	10-19 = B	4	3.33	£30,386	£9,125
40-59 = III	20-39 = C	6	4.77	£43,494	£9,118
60-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-39 = II	10-24 = B	4	3.33	£30,386	£9,125
40-59 = III	25-39 = C	6	4.77	£43,494	£9,118
60-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.75	£15,933	£9,105
20-39 = II	6-19 = B	4	3.33	£30,386	£9,125
40-54 = III	20-39 = C	6	4.77	£43,494	£9,118
55-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					



0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-39 = II	10-19 = B	4	3.33	£30,386	£9,125
40-54 = III	20-39 = C	6	4.77	£43,494	£9,118
55-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-39 = II	10-24 = B	4	3.33	£30,386	£9,125
40-54 = III	25-39 = C	6	4.77	£43,494	£9,118
55-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.75	£15,933	£9,105
20-44 = II	6-19 = B	4	3.33	£30,386	£9,125
45-54 = III	20-39 = C	6	4.77	£43,494	£9,118
55-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-44 = II	10-19 = B	4	3.33	£30,386	£9,125
45-54 = III	20-39 = C	6	4.77	£43,494	£9,118
55-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-44 = II	10-24 = B	4	3.33	£30,386	£9,125
45-54 = III	25-39 = C	6	4.77	£43,494	£9,118
55-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.75	£15,933	£9,105
20-49 = II	6-19 = B	4	3.33	£30,386	£9,125
50-64 = III	20-39 = C	6	4.77	£43,494	£9,118
65-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-49 = II	10-19 = B	4	3.33	£30,386	£9,125
50-64 = III	20-39 = C	6	4.77	£43,494	£9,118
65-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-49 = II	10-24 = B	4	3.33	£30,386	£9,125
50-64 = III	25-39 = C	6	4.77	£43,494	£9,118
65-69 = IV	40-55 = D	8	6.08	£55,383	£9,109
70-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.75	£15,933	£9,105
20-49 = II	6-19 = B	4	3.33	£30,386	£9,125
50-59 = III	20-39 = C	6	4.77	£43,494	£9,118
60-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-49 = II	10-19 = B	4	3.33	£30,386	£9,125
50-59 = III	20-39 = C	6	4.77	£43,494	£9,118
60-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.75	£15,933	£9,105
20-49 = II	10-24 = B	4	3.33	£30,386	£9,125
50-59 = III	25-39 = C	6	4.77	£43,494	£9,118
60-64 = IV	40-55 = D	8	6.08	£55,383	£9,109
65-79 = V		10	7.26	£66,167	£9,114
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.77	£15,933	£9,002
20-44 = II	6-19 = B	4	3.37	£30,386	£9,017
45-59 = III	20-39 = C	6	4.82	£43,494	£9,024
60-74 = IV	40-55 = D	8	6.14	£55,383	£9,020
75-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I	1-9 = A	2	1.77	£15,933	£9,002
20-44 = II	10-19 = B	4	3.37	£30,386	£9,017
45-59 = III	20-39 = C	6	4.82	£43,494	£9,024
60-74 = IV	40-55 = D	8	6.14	£55,383	£9,020
75-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£15,933	£9,002
20-44 = II	10-24 = B	4	3.37	£30,386	£9,017
45-59 = III	25-39 = C	6	4.82	£43,494	£9,024
60-74 = IV	40-55 = D	8	6.14	£55,383	£9,020
75-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.77	£15,933	£9,002
20-54 = II	6-19 = B	4	3.37	£30,386	£9,017
55-59 = III	20-39 = C	6	4.82	£43,494	£9,024
60-69 = IV	40-55 = D	8	6.14	£55,383	£9,020
70-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£15,933	£9,002
20-54 = II	10-19 = B	4	3.37	£30,386	£9,017
55-59 = III	20-39 = C	6	4.82	£43,494	£9,024
60-69 = IV	40-55 = D	8	6.14	£55,383	£9,020
70-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£15,933	£9,002
20-54 = II	10-24 = B	4	3.37	£30,386	£9,017
55-59 = III	25-39 = C	6	4.82	£43,494	£9,024
60-69 = IV	40-55 = D	8	6.14	£55,383	£9,020
70-79 = V		10	7.34	£66,167	£9,015
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£15,933	£9,002
20-49 = II	10-24 = B	4	3.37	£30,386	£9,017
50-54 = III	25-44 = C	6	4.82	£43,494	£9,024
55-64 = IV	45-55 = D	8	6.14	£55,383	£9,020
65-74 = V		10	7.34	£66,167	£9,015
75-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I	1-9 = A	2	1.79	£15,933	£8,901
20-39 = II	10-24 = B	4	3.40	£30,386	£8,937
40-54 = III	25-44 = C	6	4.87	£43,494	£8,931
55-69 = IV	45-55 = D	8	6.20	£55,383	£8,933
70-79 = V		10	7.41	£66,167	£8,929
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£15,933	£8,901
20-44 = II	10-24 = B	4	3.40	£30,386	£8,937
45-54 = III	25-44 = C	6	4.87	£43,494	£8,931
55-64 = IV	45-55 = D	8	6.20	£55,383	£8,933
65-79 = V		10	7.41	£66,167	£8,929
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.79	£15,933	£8,901
20-54 = II	6-19 = B	4	3.40	£30,386	£8,937
55-64 = III	20-39 = C	6	4.87	£43,494	£8,931
65-74 = IV	40-55 = D	8	6.20	£55,383	£8,933
75-79 = V		10	7.41	£66,167	£8,929
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£15,933	£8,901
20-54 = II	10-19 = B	4	3.40	£30,386	£8,937
55-64 = III	20-39 = C	6	4.87	£43,494	£8,931
65-74 = IV	40-55 = D	8	6.20	£55,383	£8,933
75-79 = V		10	7.41	£66,167	£8,929
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£15,933	£8,901
20-54 = II	10-24 = B	4	3.40	£30,386	£8,937
55-64 = III	25-39 = C	6	4.87	£43,494	£8,931
65-74 = IV	40-55 = D	8	6.20	£55,383	£8,933
75-79 = V		10	7.41	£66,167	£8,929
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£15,933	£8,901
20-49 = II	10-24 = B	4	3.40	£30,386	£8,937
50-59 = III	25-44 = C	6	4.87	£43,494	£8,931
60-69 = IV	45-55 = D	8	6.20	£55,383	£8,933
70-74 = V		10	7.41	£66,167	£8,929
75-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I	1-9 = A	2	1.80	£15,933	£8,852
20-39 = II	10-24 = B	4	3.44	£30,386	£8,833
40-59 = III	25-44 = C	6	4.92	£43,494	£8,840
60-69 = IV	45-55 = D	8	6.27	£55,383	£8,833
70-79 = V		10	7.49	£66,167	£8,834
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£15,933	£8,852
20-44 = II	10-24 = B	4	3.44	£30,386	£8,833
45-59 = III	25-44 = C	6	4.92	£43,494	£8,840
60-74 = IV	45-55 = D	8	6.27	£55,383	£8,833
75-79 = V		10	7.49	£66,167	£8,834
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£15,933	£8,852
20-54 = II	10-24 = B	4	3.44	£30,386	£8,833
55-59 = III	25-44 = C	6	4.92	£43,494	£8,840
60-69 = IV	45-55 = D	8	6.27	£55,383	£8,833
70-79 = V		10	7.49	£66,167	£8,834
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£15,933	£8,852
20-49 = II	10-24 = B	4	3.44	£30,386	£8,833
50-64 = III	25-44 = C	6	4.92	£43,494	£8,840
65-69 = IV	45-55 = D	8	6.27	£55,383	£8,833
70-79 = V		10	7.49	£66,167	£8,834
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£15,933	£8,852
20-49 = II	10-24 = B	4	3.44	£30,386	£8,833
50-59 = III	25-44 = C	6	4.92	£43,494	£8,840
60-64 = IV	45-55 = D	8	6.27	£55,383	£8,833
65-79 = V		10	7.49	£66,167	£8,834
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.82	£15,933	£8,754
20-54 = II	10-24 = B	4	3.48	£30,386	£8,732
55-64 = III	25-44 = C	6	4.97	£43,494	£8,751
65-74 = IV	45-55 = D	8	6.33	£55,383	£8,749
75-79 = V		10	7.57	£66,167	£8,741
80-89 = VI					
90-99 = VII					
100-109 = VIII					

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF HAEMODIALYSIS DATA**  
**EVANS ET AL (1984), EVANS ET AL (1985) - HOME HAEMODIALYSIS**

Conversion of Karnofsky Index into Rosser Disability/Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
A = I-IIA	2	1.75	£15,933	£9,105
B = IIIB	4	3.33	£30,386	£9,125
C = IVC	6	4.77	£43,494	£9,118
D = V-VID	8	6.08	£55,383	£9,109
E = VII-VIID	10	7.26	£66,167	£9,114
A = I-IIA	2	1.79	£15,933	£8,901
B = III-IVA	4	3.40	£30,386	£8,937
C = VB	6	4.87	£43,494	£8,931
D = VIC	8	6.20	£55,383	£8,933
E = VII-VIID	10	7.41	£66,167	£8,929
A = I-IIA	2	1.79	£15,933	£8,901
B = III-IVB	4	3.40	£30,386	£8,937
C = VC	6	4.87	£43,494	£8,931
D = VIC	8	6.20	£55,383	£8,933
E = VII-VIID	10	7.41	£66,167	£8,929
A = I-IIA	2	1.79	£15,933	£8,901
B = IIIB	4	3.40	£30,386	£8,937
C = IV-VC	6	4.87	£43,494	£8,931
D = VIC	8	6.20	£55,383	£8,933
E = VII-VIID	10	7.41	£66,167	£8,929
A = IA	2	1.80	£15,933	£8,852
B = II-IIIB	4	3.44	£30,386	£8,833
C = IV-VB	6	4.92	£43,494	£8,840
D = VIC	8	6.27	£55,383	£8,833
E = VII-VIID	10	7.49	£66,167	£8,834
A = IA	2	1.80	£15,933	£8,852
B = II-IIIB	4	3.44	£30,386	£8,833
C = IV-VC	6	4.92	£43,494	£8,840
D = VIC	8	6.27	£55,383	£8,833
E = VII-VIID	10	7.49	£66,167	£8,834
A = I-IIA	2	1.80	£15,933	£8,852
B = IIIB	4	3.44	£30,386	£8,833
C = IVB	6	4.92	£43,494	£8,840
D = V-VIC	8	6.27	£55,383	£8,833
E = VII-VIID	10	7.49	£66,167	£8,834

A = I-IIA	2	1.80	£15,933	£8,852
B = IIIA	4	3.44	£30,386	£8,833
C = IV-VB	6	4.92	£43,494	£8,840
D = VIC	8	6.27	£55,383	£8,833
E = VII-VIIID	10	7.49	£66,167	£8,834
A = IA	2	1.82	£15,933	£8,754
B = II-IIIA	4	3.48	£30,386	£8,732
C = IVB	6	4.97	£43,494	£8,751
D = V-VIC	8	6.33	£55,383	£8,749
E = VII-VIIID	10	7.57	£66,167	£8,741
A = IA	2	1.82	£15,933	£8,754
B = II-IIIB	4	3.48	£30,386	£8,732
C = IVC	6	4.97	£43,494	£8,751
D = V-VIC	8	6.33	£55,383	£8,749
E = VII-VIIID	10	7.57	£66,167	£8,741
A = IA	2	1.82	£15,933	£8,754
B = II-IIIB	4	3.48	£30,386	£8,732
C = IVC	6	4.97	£43,494	£8,751
D = VC	8	6.33	£55,383	£8,749
E = VI-VIIID	10	7.57	£66,167	£8,741
A = I-IIA	2	1.82	£15,933	£8,754
B = IIIA	4	3.48	£30,386	£8,732
C = IVB	6	4.97	£43,494	£8,751
D = VC	8	6.33	£55,383	£8,749
E = VI-VIIID	10	7.57	£66,167	£8,741
A = I-IIA	2	1.82	£15,933	£8,754
B = IIIB	4	3.48	£30,386	£8,732
C = IVC	6	4.97	£43,494	£8,751
D = VC	8	6.33	£55,383	£8,749
E = VI-VIIID	10	7.57	£66,167	£8,741
A = IA	2	1.84	£15,933	£8,659
B = II-IIIA	4	3.51	£30,386	£8,657
C = IVB	6	5.02	£43,494	£8,664
D = VC	8	6.40	£55,383	£8,654
E = VI-VIIID	10	7.64	£66,167	£8,661

EVANS ET AL (1984), EVANS ET AL (1985) - HOSPITAL HAEMODIALYSIS

Conversion of Karnofsky Index into Rosser Disability/ Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
A = I-IIA	2	1.62	£15,933	£9,835
B = IIIB	4	3.09	£30,386	£9,834
C = IVC	6	4.42	£43,494	£9,840
D = V-VID	8	5.62	£55,383	£9,855
E = VII-VIID	10	6.72	£66,167	£9,846
A = I-IIA	2	1.71	£15,933	£9,318
B = III-IVB	4	3.26	£30,386	£9,321
C = VC	6	4.67	£43,494	£9,313
D = VIC	8	5.95	£55,383	£9,308
E = VII-VIID	10	7.10	£66,167	£9,319
A = I-IIA	2	1.71	£15,933	£9,318
B = IIIB	4	3.26	£30,386	£9,321
C = IV-VC	6	4.67	£43,494	£9,313
D = VIC	8	5.95	£55,383	£9,308
E = VII-VIID	10	7.10	£66,167	£9,319
A = IA	2	1.73	£15,933	£9,210
B = II-III B	4	3.30	£30,386	£9,208
C = IV-VB	6	4.72	£43,494	£9,215
D = VIC	8	6.01	£55,383	£9,215
E = VII-VIID	10	7.18	£66,167	£9,215
A = IA	2	1.73	£15,933	£9,210
B = II-III B	4	3.30	£30,386	£9,208
C = IV-VC	6	4.72	£43,494	£9,215
D = VIC	8	6.01	£55,383	£9,215
E = VII-VIID	10	7.18	£66,167	£9,215
A = I-IIA	2	1.73	£15,933	£9,210
B = III-IVA	4	3.30	£30,386	£9,208
C = VB	6	4.72	£43,494	£9,215
D = VIC	8	6.01	£55,383	£9,215
E = VII-VIID	10	7.18	£66,167	£9,215
A = I-IIA	2	1.73	£15,933	£9,210
B = IIIA	4	3.30	£30,386	£9,208
C = IV-VB	6	4.72	£43,494	£9,215
D = VIC	8	6.01	£55,383	£9,215
E = VII-VIID	10	7.18	£66,167	£9,215



A = IA	2	1.77	£15,933	£9,002
B = II-III A	4	3.37	£30,386	£9,017
C = IVB	6	4.82	£43,494	£9,024
D = V-VIC	8	6.14	£55,383	£9,020
E = VII-VIII D	10	7.34	£66,167	£9,015
A = IA	2	1.77	£15,933	£9,002
B = II-III B	4	3.37	£30,386	£9,017
C = IVC	6	4.82	£43,494	£9,024
D = V-VIC	8	6.14	£55,383	£9,020
E = VII-VIII D	10	7.34	£66,167	£9,015
A = I-II A	2	1.77	£15,933	£9,002
B = III B	4	3.37	£30,386	£9,017
C = IVB	6	4.82	£43,494	£9,024
D = V-VIC	8	6.14	£55,383	£9,020
E = VII-VIII D	10	7.34	£66,167	£9,015
A = I-II A	2	1.79	£15,933	£8,901
B = III B	4	3.40	£30,386	£8,937
C = IVC	6	4.87	£43,494	£8,931
D = VC	8	6.20	£55,383	£8,933
E = VI-VIII D	10	7.41	£66,167	£8,929
A = IA	2	1.80	£15,933	£8,852
B = II-III A	4	3.44	£30,386	£8,833
C = IVB	6	4.92	£43,494	£8,840
D = VC	8	6.27	£55,383	£8,833
E = VI-VIII D	10	7.49	£66,167	£8,834
A = IA	2	1.80	£15,933	£8,852
B = II-III B	4	3.44	£30,386	£8,833
C = IVC	6	4.92	£43,494	£8,840
D = VC	8	6.27	£55,383	£8,833
E = VI-VIII D	10	7.49	£66,167	£8,834
A = I-II A	2	1.80	£15,933	£8,852
B = III A	4	3.44	£30,386	£8,833
C = IVB	6	4.92	£43,494	£8,840
D = VC	8	6.27	£55,383	£8,833
E = VI-VIII D	10	7.49	£66,167	£8,834

**SENSITIVITY ANALYSIS OF GUDEx'S USE OF RENAL TRANSPLANT DATA  
PROCCI (1980)**

Conversion of Social Disability Scores into Rosser Disability Categories	Conversion of Social Modifiers into Rosser Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
0-20 = I	1-9 = A	2	1.77	£10,452	£5,905
20-39 = II	10-24 = B	4	3.37	£10,452	£3,101
40-59 = III	25-34 = C	6	4.82	£10,452	£2,168
60-69 = IV	35-55 = D	8	6.14	£10,452	£1,702
70-79 = V		10	7.34	£10,452	£1,424
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£10,452	£5,905
20-39 = II	10-24 = B	4	3.37	£10,452	£3,101
40-54 = III	25-34 = C	6	4.82	£10,452	£2,168
55-69 = IV	35-55 = D	8	6.14	£10,452	£1,702
70-79 = V		10	7.34	£10,452	£1,424
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£10,452	£5,905
20-44 = II	10-24 = B	4	3.37	£10,452	£3,101
45-54 = III	25-34 = C	6	4.82	£10,452	£2,168
55-64 = IV	35-55 = D	8	6.14	£10,452	£1,702
65-79 = V		10	7.34	£10,452	£1,424
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.77	£10,452	£5,905
20-49 = II	10-24 = B	4	3.37	£10,452	£3,101
50-54 = III	25-34 = C	6	4.82	£10,452	£2,168
55-64 = IV	35-55 = D	8	6.14	£10,452	£1,702
65-74 = V		10	7.34	£10,452	£1,424
75-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I	1-5 = A	2	1.79	£10,452	£5,839
20-39 = II	6-19 = B	4	3.40	£10,452	£3,074
40-59 = III	20-39 = C	6	4.87	£10,452	£2,146
60-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£10,452	£5,839
20-39 = II	10-19 = B	4	3.40	£10,452	£3,074
40-59 = III	20-39 = C	6	4.87	£10,452	£2,146
60-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.79	£10,452	£5,839
20-39 = II	6-19 = B	4	3.40	£10,452	£3,074
40-54 = III	20-39 = C	6	4.87	£10,452	£2,146
55-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£10,452	£5,839
20-39 = II	10-19 = B	4	3.40	£10,452	£3,074
40-54 = III	20-39 = C	6	4.87	£10,452	£2,146
55-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£10,452	£5,839
20-39 = II	10-24 = B	4	3.40	£10,452	£3,074
40-54 = III	25-39 = C	6	4.87	£10,452	£2,146
55-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-5 = A	2	1.79	£10,452	£5,839
20-44 = II	6-19 = B	4	3.40	£10,452	£3,074
45-54 = III	20-39 = C	6	4.87	£10,452	£2,146
55-64 = IV	40-55 = D	8	6.20	£10,452	£1,686
65-79 = V		10	7.41	£10,452	£1,411
80-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I 20-44 = II 45-54 = III 55-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-44 = II 45-54 = III 55-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-44 = II 45-59 = III 60-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-54 = II 55-59 = III 60-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-34 = C 35-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411

0-20 = I 20-49 = II 50-54 = III 55-64 = IV 65-74 = V 75-89 = VI 90-99 = VII 100-109=VIII	1-9 = A 10-24 = B 25-39 = C 40-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-64 = III 65-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109=VIII	1-5 = A 6-19 = B 20-39 = C 40-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-64 = III 65-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109=VIII	1-9 = A 10-24 = B 25-34 = C 35-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-59 = III 60-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109=VIII	1-5 = A 6-19 = B 20-39 = C 40-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-59 = III 60-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109=VIII	1-9 = A 10-19 = B 20-39 = C 40-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411
0-20 = I 20-49 = II 50-59 = III 60-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109=VIII	1-9 = A 10-24 = B 25-34 = C 35-55 =D	2 4 6 8 10	1.79 3.40 4.87 6.20 7.41	£10,452 £10,452 £10,452 £10,452 £10,452	£5,839 £3,074 £2,146 £1,686 £1,411

0-20 = I	1-5 = A	2	1.79	£10,452	£5,839
20-49 = II	6-19 = B	4	3.40	£10,452	£3,074
50-59 = III	20-39 = C	6	4.87	£10,452	£2,146
60-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-74 = V		10	7.41	£10,452	£1,411
75-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£10,452	£5,839
20-49 = II	10-19 = B	4	3.40	£10,452	£3,074
50-59 = III	20-39 = C	6	4.87	£10,452	£2,146
60-69 = IV	40-55 = D	8	6.20	£10,452	£1,686
70-74 = V		10	7.41	£10,452	£1,411
75-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.79	£10,452	£5,839
20-49 = II	10-24 = B	4	3.40	£10,452	£3,074
50-59 = III	25-34 = C	6	4.87	£10,452	£2,146
60-69 = IV	35-55 = D	8	6.20	£10,452	£1,686
70-74 = V		10	7.41	£10,452	£1,411
75-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£10,452	£5,807
20-39 = II	10-24 = B	4	3.44	£10,452	£3,038
40-59 = III	25-39 = C	6	4.92	£10,452	£2,124
60-69 = IV	40-55 = D	8	6.27	£10,452	£1,667
70-79 = V		10	7.49	£10,452	£1,395
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£10,452	£5,807
20-44 = II	10-19 = B	4	3.44	£10,452	£3,038
45-59 = III	20-39 = C	6	4.92	£10,452	£2,124
60-74 = IV	40-55 = D	8	6.27	£10,452	£1,667
75-79 = V		10	7.49	£10,452	£1,395
80-89 = VI					
90-99 = VII					
100-109 = VIII					
0-20 = I	1-9 = A	2	1.80	£10,452	£5,807
20-44 = II	10-24 = B	4	3.44	£10,452	£3,038
45-59 = III	25-39 = C	6	4.92	£10,452	£2,124
60-74 = IV	40-55 = D	8	6.27	£10,452	£1,667
75-79 = V		10	7.49	£10,452	£1,395
80-89 = VI					
90-99 = VII					
100-109 = VIII					

0-20 = I 20-44 = II 45-59 = III 60-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-34 = C 35-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-59 = III 60-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-59 = III 60-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-59 = III 60-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-64 = III 65-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-5 = A 6-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-64 = III 65-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395

0-20 = I 20-54 = II 55-64 = III 65-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-34 = C 35-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-49 = II 50-64 = III 65-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-19 = B 20-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-49 = II 50-64 = III 65-69 = IV 70-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-49 = II 50-59 = III 60-64 = IV 65-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-49 = II 50-59 = III 60-69 = IV 70-74 = V 75-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.80 3.44 4.92 6.27 7.49	£10,452 £10,452 £10,452 £10,452 £10,452	£5,807 £3,038 £2,124 £1,667 £1,395
0-20 = I 20-54 = II 55-64 = III 65-74 = IV 75-79 = V 80-89 = VI 90-99 = VII 100-109 = VIII	1-9 = A 10-24 = B 25-39 = C 40-55 = D	2 4 6 8 10	1.82 3.48 4.97 6.33 7.57	£10,452 £10,452 £10,452 £10,452 £10,452	£5,743 £3,003 £2,103 £1,651 £1,381



**SENSITIVITY ANALYSIS OF GUDEX'S USE OF RENAL TRANSPLANT DATA**  
**EVANS ET AL (1984), EVANS ET AL (1985)**

Conversion of Karnofsky Index into Rosser Disability/Distress Categories	Survival (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
A = I-IIA	2	1.75	£10,452	£5,973
B = IIIB	4	3.33	£10,452	£3,139
C = IVC	6	4.77	£10,452	£2,191
D = V-VID	8	6.08	£10,452	£1,719
E = VII-VIID	10	7.26	£10,452	£1,440
A = I-IIA	2	1.79	£10,452	£5,839
B = III-IVB	4	3.40	£10,452	£3,074
C = VC	6	4.87	£10,452	£2,146
D = VIC	8	6.20	£10,452	£1,686
E = VII-VIID	10	7.41	£10,452	£1,411
A = IA	2	1.80	£10,452	£5,807
B = II-III B	4	3.44	£10,452	£3,038
C = IV-VB	6	4.92	£10,452	£2,124
D = VIC	8	6.27	£10,452	£1,667
E = VII-VIID	10	7.49	£10,452	£1,395
A = IA	2	1.80	£10,452	£5,807
B = II-III B	4	3.44	£10,452	£3,038
C = IV-VC	6	4.92	£10,452	£2,124
D = VIC	8	6.27	£10,452	£1,667
E = VII-VIID	10	7.49	£10,452	£1,395
A = I-IIA	2	1.80	£10,452	£5,807
B = III-IVA	4	3.44	£10,452	£3,038
C = VB	6	4.92	£10,452	£2,124
D = VIC	8	6.27	£10,452	£1,667
E = VII-VIID	10	7.49	£10,452	£1,395
A = I-IIA	2	1.80	£10,452	£5,807
B = IIIA	4	3.44	£10,452	£3,038
C = IV-VB	6	4.92	£10,452	£2,124
D = VIC	8	6.27	£10,452	£1,667
E = VII-VIID	10	7.49	£10,452	£1,395
A = I-IIA	2	1.80	£10,452	£5,807
B = IIIB	4	3.44	£10,452	£3,038
C = IV-VC	6	4.92	£10,452	£2,124
D = VIC	8	6.27	£10,452	£1,667
E = VII-VIID	10	7.49	£10,452	£1,395

A = IA	2	1.82	£10,452	£5,743
B = II-III A	4	3.48	£10,452	£3,003
C = IVB	6	4.97	£10,452	£2,103
D = V-VIC	8	6.33	£10,452	£1,651
E = VII-VIII D	10	7.57	£10,452	£1,381
A = IA	2	1.82	£10,452	£5,743
B = II-III B	4	3.48	£10,452	£3,003
C = IVC	6	4.97	£10,452	£2,103
D = V-VIC	8	6.33	£10,452	£1,651
E = VII-VIII D	10	7.57	£10,452	£1,381
A = I-II A	2	1.82	£10,452	£5,743
B = III B	4	3.48	£10,452	£3,003
C = IVB	6	4.97	£10,452	£2,103
D = V-VIC	8	6.33	£10,452	£1,651
E = VII-VIII D	10	7.57	£10,452	£1,381
A = I-II A	2	1.82	£10,452	£5,743
B = III A	4	3.48	£10,452	£3,003
C = IVB	6	4.97	£10,452	£2,103
D = VC	8	6.33	£10,452	£1,651
E = VI-VIII D	10	7.57	£10,452	£1,381
A = I-II A	2	1.82	£10,452	£5,743
B = III B	4	3.48	£10,452	£3,003
C = IVC	6	4.97	£10,452	£2,103
D = VC	8	6.33	£10,452	£1,651
E = VI-VIII D	10	7.57	£10,452	£1,381
A = IA	2	1.84	£10,452	£5,680
B = II-III A	4	3.51	£10,452	£2,978
C = IVB	6	5.02	£10,452	£2,082
D = VC	8	6.40	£10,452	£1,633
E = VI-VIII D	10	7.64	£10,452	£1,368
A = IA	2	1.84	£10,452	£5,680
B = II-III B	4	3.51	£10,452	£2,978
C = IVC	6	5.02	£10,452	£2,082
D = VC	8	6.40	£10,452	£1,633
E = VI-VIII D	10	7.64	£10,452	£1,368

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF SHOULDER JOINT  
REPLACEMENT SURGERY DATA  
COFIELD (1984) - RHEUMATOID ARTHRITIS**

Conversion of Full Exercise Programme Categories into Rosser Categories - Postoperative	Sensitivity Analysis of Preoperative Rosser Categories	Duration of Joint (Years)	QALY's Gained per Patient-Discounted at 5%	Total Costs	Cost per QALY
A = IA B = IB C = IIIB D = IIIA E = IVB	III C	5 8 10 15	0.15 0.22 0.26 0.35	£533 £533 £533 £533	£3,553 £2,423 £2,050 £1,523
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC	5 8 10 15	0.18 0.26 0.32 0.43	£533 £533 £533 £533	£2,961 £2,050 £1,666 £1,240
A = IA B = IB C = IIIB D = IIIA E = IVB	IV C	5 8 10 15	0.21 0.31 0.37 0.50	£533 £533 £533 £533	£2,538 £1,719 £1,441 £1,066
A = IA B = IB C = IIIB D = IIIA E = IVB	III C-D	5 8 10 15	0.24 0.36 0.43 0.58	£533 £533 £533 £533	£2,221 £1,481 £1,240 £919
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC	5 8 10 15	0.25 0.37 0.44 0.60	£533 £533 £533 £533	£2,132 £1,441 £1,211 £888
A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VC	5 8 10 15	0.30 0.45 0.53 0.72	£533 £533 £533 £533	£1,777 £1,184 £1,006 £740
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730

A = IA B = IB C = IIIB D = IIIA E = IVB	IID	5 8 10 15	0.34 0.50 0.60 0.81	£533 £533 £533 £533	£1,568 £1,066 £888 £658
A = IA B = IB C = IIIB D = IIIA E = IVB	IVC-D	5 8 10 15	0.36 0.54 0.65 0.87	£533 £533 £533 £533	£1,481 £987 £820 £613
A = IA B = IB C = IIIB D = IIIA E = IVB	VC	5 8 10 15	0.39 0.58 0.69 0.93	£533 £533 £533 £533	£1,367 £919 £772 £573
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVD	5 8 10 15	0.43 0.64 0.76 1.03	£533 £533 £533 £533	£1,240 £833 £701 £517
A = IA B = IB C = IIIB D = IIIA E = IVB	III-VC-D	5 8 10 15	0.48 0.71 0.85 1.14	£533 £533 £533 £533	£1,110 £751 £627 £468
A = IA B = IB C = IIIB D = IIIA E = IVB	IVD	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VC-D	5 8 10 15	0.59 0.89 1.06 1.42	£533 £533 £533 £533	£903 £599 £503 £375
A = IA B = IB C = IIIB D = IIIA E = IVB	III-VD	5 8 10 15	0.70 1.05 1.26 1.69	£533 £533 £533 £533	£761 £508 £423 £315
A = IA B = IB C = IIIB D = IIIA E = IVB	VC-D	5 8 10 15	0.82 1.23 1.47 1.97	£533 £533 £533 £533	£650 £433 £363 £271

A = IA B = IB C = IIB D = IIIA E = IVB	IV-VD	5 8 10 15	0.89 1.32 1.58 2.13	£533 £533 £533 £533	£599 £404 £337 £250
A = IA B = IB C = IIB D = IIIA E = IVB	VD	5 8 10 15	1.26 1.87 2.24 3.01	£533 £533 £533 £533	£423 £285 £238 £177
A = IA B = IIB C = IVC D = IIIC E = VC	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = IIB C = IVC D = IIIC E = VC	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = IIB C = IVC D = IIIC E = VC	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367
A = IA B = IIB C = IVC D = IIIC E = VC	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIB C = IVC D = IIIC E = VC	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808
A = IA B = IIB C = IVC D = IIIC E = VC	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650
A = IA B = IIB C = IVC D = IIIC E = VC	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513

A = IA B = IIB C = IVC D = IIIC E = VC	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IIB C = IVC D = IIIC E = VC	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IA B = IIB C = IVC D = IIIC E = VC	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650

A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IA B = IIB C = IIB D = IVB E = VD	III-IVC	5 8 10 15	0.05 0.07 0.08 0.11	£533 £533 £533 £533	£10,660 £7,614 £6,663 £4,845
A = IA B = IIB C = IIB D = IVB E = VD	IIIC-D	5 8 10 15	0.11 0.17 0.20 0.27	£533 £533 £533 £533	£4,845 £3,135 £2,665 £1,974
A = IA B = IIB C = IIB D = IVB E = VD	IV-VC	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333
A = IA B = IIB C = IIB D = IVB E = VD	IIID	5 8 10 15	0.21 0.31 0.37 0.50	£533 £533 £533 £533	£2,538 £1,719 £1,441 £1,066
A = IA B = IIB C = IIB D = IVB E = VD	VC	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860

A = IA B = IIB C = IIIB D = IVB E = VD	III-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642
A = IA B = IIB C = IIIB D = IVB E = VD	IV-VC-D	5 8 10 15	0.46 0.69 0.83 1.11	£533 £533 £533 £533	£1,159 £772 £642 £480
A = IA B = IIB C = IIIB D = IVB E = VD	III-VD	5 8 10 15	0.57 0.86 1.02 1.38	£533 £533 £533 £533	£935 £620 £523 £386
A = IA B = IIB C = IIIB D = IVB E = VD	IV-VD	5 8 10 15	0.76 1.13 1.35 1.82	£533 £533 £533 £533	£701 £472 £395 £293
A = IA B = IIB C = IIIB D = IVB E = VD	VD	5 8 10 15	1.13 1.68 2.01 2.70	£533 £533 £533 £533	£472 £317 £265 £197
A = IA B = IIB C = IIID D = IVB E = VD	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IA B = IIB C = IIID D = IVB E = VD	IIIC-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135
A = IA B = IIB C = IIID D = IVB E = VD	IV-VC	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IA B = IIB C = IIID D = IVB E = VD	IIID	5 8 10 15	0.16 0.25 0.29 0.39	£533 £533 £533 £533	£3,331 £2,132 £1,838 £1,367



A = IA B = IIB C = IID D = IVB E = VD	VC	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIB C = IID D = IVB E = VD	III-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIB C = IID D = IVB E = VD	IV-VC-D	5 8 10 15	0.42 0.63 0.75 1.01	£533 £533 £533 £533	£1,269 £846 £711 £528
A = IA B = IIB C = IID D = IVB E = VD	III-VD	5 8 10 15	0.53 0.79 0.95 1.27	£533 £533 £533 £533	£1,006 £675 £561 £420
A = IA B = IIB C = IID D = IVB E = VD	IV-VD	5 8 10 15	0.71 1.07 1.27 1.71	£533 £533 £533 £533	£751 £498 £420 £312
A = IA B = IIB C = IID D = IVB E = VD	VD	5 8 10 15	1.08 1.62 1.93 2.59	£533 £533 £533 £533	£494 £329 £276 £206
A = IA B = IIB C = IVC D = VB-C E = VD	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IA B = IIB C = IVC D = VB-C E = VD	III-C-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135
A = IA B = IIB C = IVC D = VB-C E = VD	IV-VC	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777

A = IA B = IIIB C = IVC D = VB-C E = VD	IIID	5 8 10 15	0.16 0.25 0.29 0.39	£533 £533 £533 £533	£3,331 £2,132 £1,838 £1,367
A = IA B = IIIB C = IVC D = VB-C E = VD	VC	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIIB C = IVC D = VB-C E = VD	III-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIIB C = IVC D = VB-C E = VD	IV-VC-D	5 8 10 15	0.42 0.63 0.75 1.01	£533 £533 £533 £533	£1,269 £846 £711 £528
A = IA B = IIIB C = IVC D = VB-C E = VD	III-VD	5 8 10 15	0.53 0.79 0.95 1.27	£533 £533 £533 £533	£1,006 £675 £561 £420
A = IA B = IIIB C = IVC D = VB-C E = VD	IV-VD	5 8 10 15	0.71 1.07 1.27 1.71	£533 £533 £533 £533	£751 £498 £420 £312
A = IA B = IIIB C = IVC D = VB-C E = VD	VD	5 8 10 15	1.08 1.62 1.93 2.59	£533 £533 £533 £533	£494 £329 £276 £206
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IIIC-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135

A = IB	IV-VC	5	0.13	£533	£4,100
B = IIIB		8	0.19	£533	£2,805
C = IVC		10	0.22	£533	£2,423
D = IV-VB-C		15	0.30	£533	£1,777
E = VC-D					
A = IB	IIID	5	0.16	£533	£3,331
B = IIIB		8	0.25	£533	£2,132
C = IVC		10	0.29	£533	£1,838
D = IV-VB-C		15	0.39	£533	£1,367
E = VC-D					
A = IB	VC	5	0.22	£533	£2,423
B = IIIB		8	0.32	£533	£1,666
C = IVC		10	0.39	£533	£1,367
D = IV-VB-C		15	0.52	£533	£1,025
E = VC-D					
A = IB	III-VC-D	5	0.30	£533	£1,777
B = IIIB		8	0.45	£533	£1,184
C = IVC		10	0.54	£533	£987
D = IV-VB-C		15	0.73	£533	£730
E = VC-D					
A = IB	IV-VC-D	5	0.42	£533	£1,269
B = IIIB		8	0.63	£533	£846
C = IVC		10	0.75	£533	£711
D = IV-VB-C		15	1.01	£533	£528
E = VC-D					
A = IB	III-VD	5	0.53	£533	£1,006
B = IIIB		8	0.79	£533	£675
C = IVC		10	0.95	£533	£561
D = IV-VB-C		15	1.27	£533	£420
E = VC-D					
A = IB	IV-VD	5	0.71	£533	£751
B = IIIB		8	1.07	£533	£498
C = IVC		10	1.27	£533	£420
D = IV-VB-C		15	1.71	£533	£312
E = VC-D					
A = IB	VD	5	1.08	£533	£494
B = IIIB		8	1.62	£533	£329
C = IVC		10	1.93	£533	£276
D = IV-VB-C		15	2.59	£533	£206
E = VC-D					
A = IA	IIIC-D	5	0.03	£533	£17,767
B = IIC		8	0.04	£533	£13,325
C = III-VC-D		10	0.05	£533	£10,660
D = IVB		15	0.06	£533	£8,883
E = VD					

A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VC	5 8 10 15	0.08 0.12 0.15 0.20	£533 £533 £533 £533	£6,663 £4,442 £3,553 £2,665
A = IA B = IIC C = III-VC-D D = IVB E = VD	IIID	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = IIC C = III-VC-D D = IVB E = VD	VC	5 8 10 15	0.17 0.26 0.31 0.42	£533 £533 £533 £533	£3,135 £2,050 £1,719 £1,269
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-VC-D	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.38 0.56 0.67 0.90	£533 £533 £533 £533	£1,403 £952 £796 £592
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-VD	5 8 10 15	0.49 0.73 0.87 1.17	£533 £533 £533 £533	£1,088 £730 £613 £456
A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VD	5 8 10 15	0.67 1.00 1.20 1.61	£533 £533 £533 £533	£796 £533 £444 £331
A = IA B = IIC C = III-VC-D D = IVB E = VD	VD	5 8 10 15	1.04 1.55 1.85 2.49	£533 £533 £533 £533	£513 £344 £288 £214
A = IA B = II-III-A-B C = IV-VC-D D = IVB-C E = VC-D	IIIC-D	5 8 10 15	0.03 0.04 0.05 0.06	£533 £533 £533 £533	£17,767 £13,325 £10,660 £8,883

A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	IV-VC	5 8 10 15	0.08 0.12 0.15 0.20	£533 £533 £533 £533	£6,663 £4,442 £3,553 £2,665
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	III D	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	VC	5 8 10 15	0.17 0.26 0.31 0.42	£533 £533 £533 £533	£3,135 £2,050 £1,719 £1,269
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	III-VC-D	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	IV-VC-D	5 8 10 15	0.38 0.56 0.67 0.90	£533 £533 £533 £533	£1,403 £952 £796 £592
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	III-VD	5 8 10 15	0.49 0.73 0.87 1.17	£533 £533 £533 £533	£1,088 £730 £613 £456
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	IV-VD	5 8 10 15	0.67 1.00 1.20 1.61	£533 £533 £533 £533	£796 £533 £444 £331
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10 15	1.04 1.55 1.85 2.49	£533 £533 £533 £533	£513 £344 £288 £214
A = IA B = IIB C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330

A = IA B = IIB C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10 15	0.10 0.16 0.19 0.25	£533 £533 £533 £533	£5,330 £3,331 £2,805 £2,132
A = IA B = IIB C = IV-VC-D D = IVB E = VD	III-IVD	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333
A = IA B = IIB C = IV-VC-D D = IVB E = VD	IVD	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = IIB C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642
A = IA B = IIB C = IV-VC-D D = IVB E = VD	VC-D	5 8 10 15	0.56 0.84 1.00 1.35	£533 £533 £533 £533	£952 £635 £533 £395
A = IA B = IIB C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.00 1.49 1.78 2.39	£533 £533 £533 £533	£533 £358 £299 £223
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10 15	0.10 0.16 0.19 0.25	£533 £533 £533 £533	£5,330 £3,331 £2,805 £2,132
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-IVD	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333

A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IVD	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VC-D	5 8 10 15	0.56 0.84 1.00 1.35	£533 £533 £533 £533	£952 £635 £533 £395
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.00 1.49 1.78 2.39	£533 £533 £533 £533	£533 £358 £299 £223
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10 15	0.10 0.16 0.19 0.25	£533 £533 £533 £533	£5,330 £3,331 £2,805 £2,132
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-IVD	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IVD	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642

A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VC-D	5 8 10 15	0.56 0.84 1.00 1.35	£533 £533 £533 £533	£952 £635 £533 £395
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.00 1.49 1.78 2.39	£533 £533 £533 £533	£533 £358 £299 £223
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III-IVC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IVC-D	5 8 10 15	0.10 0.16 0.19 0.25	£533 £533 £533 £533	£5,330 £3,331 £2,805 £2,132
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III-IVD	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IVD	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IV-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	VC-D	5 8 10 15	0.56 0.84 1.00 1.35	£533 £533 £533 £533	£952 £635 £533 £395
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10 15	1.00 1.49 1.78 2.39	£533 £533 £533 £533	£533 £358 £299 £223



A = IB	III-IVC-D	5	0.04	£533	£13,325
B = IIB-C		8	0.06	£533	£8,883
C = IIIB-C		10	0.08	£533	£6,663
D = IV-VC		15	0.10	£533	£5,330
E = VIC-D					
A = IB	IVC-D	5	0.10	£533	£5,330
B = IIB-C		8	0.16	£533	£3,331
C = IIIB-C		10	0.19	£533	£2,805
D = IV-VC		15	0.25	£533	£2,132
E = VIC-D					
A = IB	III-IVD	5	0.17	£533	£3,135
B = IIB-C		8	0.25	£533	£2,132
C = IIIB-C		10	0.30	£533	£1,777
D = IV-VC		15	0.40	£533	£1,333
E = VIC-D					
A = IB	IVD	5	0.26	£533	£2,050
B = IIB-C		8	0.39	£533	£1,367
C = IIIB-C		10	0.46	£533	£1,159
D = IV-VC		15	0.62	£533	£860
E = VIC-D					
A = IB	IV-VC-D	5	0.35	£533	£1,523
B = IIB-C		8	0.52	£533	£1,025
C = IIIB-C		10	0.62	£533	£860
D = IV-VC		15	0.83	£533	£642
E = VIC-D					
A = IB	VC-D	5	0.56	£533	£952
B = IIB-C		8	0.84	£533	£635
C = IIIB-C		10	1.00	£533	£533
D = IV-VC		15	1.35	£533	£395
E = VIC-D					
A = IB	VD	5	1.00	£533	£533
B = IIB-C		8	1.49	£533	£358
C = IIIB-C		10	1.78	£533	£299
D = IV-VC		15	2.39	£533	£223
E = VIC-D					
A = IA	IVC-D	5	0.06	£533	£8,883
B = IIIC		8	0.09	£533	£5,922
C = IV-VC-D		10	0.11	£533	£4,845
D = IVB		15	0.15	£533	£3,553
E = VD					
A = IA	III-IVD	5	0.13	£533	£4,100
B = IIIC		8	0.19	£533	£2,805
C = IV-VC-D		10	0.22	£533	£2,423
D = IVB		15	0.30	£533	£1,777
E = VD					

A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IVD	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	0.95 1.42 1.70 2.28	£533 £533 £533 £533	£561 £375 £314 £234
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IVC-D	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	III-IVD	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IVD	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IV-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426

A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	VD	5 8 10 15	0.95 1.42 1.70 2.28	£533 £533 £533 £533	£561 £375 £314 £234
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	III-VC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VC-D	5 8 10 15	0.16 0.24 0.29 0.38	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,403
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	III-VD	5 8 10 15	0.27 0.41 0.48 0.65	£533 £533 £533 £533	£1,974 £1,300 £1,110 £820
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VD	5 8 10 15	0.45 0.68 0.81 1.09	£533 £533 £533 £533	£1,184 £784 £658 £489
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	VD	5 8 10 15	0.82 1.23 1.47 1.97	£533 £533 £533 £533	£650 £433 £363 £271
A = IA B = II-III B C = IVC D = V-VIB-C E = IVD	III-VC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IA B = II-III B C = IVC D = V-VIB-C E = IVD	IV-VC-D	5 8 10 15	0.16 0.24 0.29 0.38	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,403
A = IA B = II-III B C = IVC D = V-VIB-C E = IVD	III-VD	5 8 10 15	0.27 0.41 0.48 0.65	£533 £533 £533 £533	£1,974 £1,300 £1,110 £820

A = IA B = II-III B C = IVC D = V-VIB-C E = IVD	IV-VD	5 8 10 15	0.45 0.68 0.81 1.09	£533 £533 £533 £533	£1,184 £784 £658 £489
A = IA B = II-III B C = IVC D = V-VIB-C E = IVD	VD	5 8 10 15	0.82 1.23 1.47 1.97	£533 £533 £533 £533	£650 £433 £363 £271
A = IB B = IIB C = VD D = IVB E = V-VIC-D	III-VC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IB B = IIB C = VD D = IVB E = V-VIC-D	IV-VC-D	5 8 10 15	0.16 0.24 0.29 0.38	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,403
A = IB B = IIB C = VD D = IVB E = V-VIC-D	III-VD	5 8 10 15	0.27 0.41 0.48 0.65	£533 £533 £533 £533	£1,974 £1,300 £1,110 £820
A = IB B = IIB C = VD D = IVB E = V-VIC-D	IV-VD	5 8 10 15	0.45 0.68 0.81 1.09	£533 £533 £533 £533	£1,184 £784 £658 £489
A = IB B = IIB C = VD D = IVB E = V-VIC-D	VD	5 8 10 15	0.82 1.23 1.47 1.97	£533 £533 £533 £533	£650 £433 £363 £271
A = IB B = IIIC C = VD D = VIC E = VID	VC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IB B = IIIC C = VD D = VIC E = VID	VD	5 8 10 15	0.48 0.71 0.85 1.14	£533 £533 £533 £533	£1,110 £751 £627 £468

## COFIELD (1984) - OSTEOARTHRITIS

Conversion of Full Exercise Programme Categories into Rosser Categories - Postoperative	Sensitivity Analysis of Preoperative Rosser Categories	Duration of Joint (Years)	QALY's Gained per Patient-Discounted at 5%	Total Costs	Cost per QALY
A = IA B = IB C = IIIB D = IIIA E = IVB	IIIC	5 8 10	0.15 0.22 0.26	£533 £533 £533	£3,553 £2,423 £2,050
A = IA B = IB C = IIIB D = IIIA E = IVB	IIIC-D	5 8 10	0.24 0.36 0.43	£533 £533 £533	£2,221 £1,481 £1,240
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC-D	5 8 10	0.30 0.45 0.54	£533 £533 £533	£1,777 £1,184 £987
A = IA B = IB C = IIIB D = IIIA E = IVB	VC	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IB C = IIIB D = IIIA E = IVB	IVD	5 8 10	0.52 0.78 0.93	£533 £533 £533	£1,025 £683 £573
A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VC-D	5 8 10	0.61 0.90 1.08	£533 £533 £533	£874 £592 £494
A = IA B = IB C = IIIB D = IIIA E = IVB	VC-D	5 8 10	0.82 1.23 1.47	£533 £533 £533	£650 £433 £363

A = IA B = IB C = IIIB D = IIIA E = IVB	VD	5 8 10	1.26 1.87 2.24	£533 £533 £533	£423 £285 £238
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IIIC	5 8 10	0.15 0.22 0.26	£533 £533 £533	£3,553 £2,423 £2,050
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IIIC-D	5 8 10	0.24 0.36 0.43	£533 £533 £533	£2,221 £1,481 £1,240
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-IVC-D	5 8 10	0.30 0.45 0.54	£533 £533 £533	£1,777 £1,184 £987
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VC	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IVD	5 8 10	0.52 0.78 0.93	£533 £533 £533	£1,025 £683 £573
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IV-VC-D	5 8 10	0.61 0.90 1.08	£533 £533 £533	£874 £592 £494
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VC-D	5 8 10	0.82 1.23 1.47	£533 £533 £533	£650 £433 £363
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VD	5 8 10	1.26 1.87 2.24	£533 £533 £533	£423 £285 £238

A = IA B = IIB C = IIIB D = IVB E = VD	III-IVC	5 8 10	0.13 0.20 0.24	£533 £533 £533	£4,100 £2,665 £2,221
A = IA B = IIB C = IIIB D = IVB E = VD	III-VC	5 8 10	0.20 0.31 0.37	£533 £533 £533	£2,665 £1,719 £1,441
A = IA B = IIB C = IIIB D = IVB E = VD	IIID	5 8 10	0.29 0.44 0.53	£533 £533 £533	£1,838 £1,211 £1,006
A = IA B = IIB C = IIIB D = IVB E = VD	III-IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIB C = IIIB D = IVB E = VD	IV-VC-D	5 8 10	0.55 0.82 0.98	£533 £533 £533	£969 £650 £544
A = IA B = IIB C = IIIB D = IVB E = VD	VC-D	5 8 10	0.78 1.16 1.39	£533 £533 £533	£683 £459 £383
A = IA B = IIB C = IIIB D = IVB E = VD	VD	5 8 10	1.21 1.81 2.16	£533 £533 £533	£440 £294 £247
A = IA B = IIB C = IVC D = IIIC E = VC	III-IVC	5 8 10	0.13 0.20 0.24	£533 £533 £533	£4,100 £2,665 £2,221
A = IA B = IIB C = IVC D = IIIC E = VC	III-VC	5 8 10	0.20 0.31 0.37	£533 £533 £533	£2,665 £1,719 £1,441

A = IA B = IIB C = IVC D = IIIC E = VC	IIID	5 8 10	0.29 0.44 0.53	£533 £533 £533	£1,838 £1,211 £1,006
A = IA B = IIB C = IVC D = IIIC E = VC	III-IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIB C = IVC D = IIIC E = VC	IV-VC-D	5 8 10	0.55 0.82 0.98	£533 £533 £533	£969 £650 £544
A = IA B = IIB C = IVC D = IIIC E = VC	VC-D	5 8 10	0.78 1.16 1.39	£533 £533 £533	£683 £459 £383
A = IA B = IIB C = IVC D = IIIC E = VC	VD	5 8 10	1.21 1.81 2.16	£533 £533 £533	£440 £294 £247
A = IA B = IIB C = IIID D = IVB E = VD	IVC	5 8 10	0.12 0.18 0.22	£533 £533 £533	£4,442 £2,961 £2,423
A = IA B = IIB C = IIID D = IVB E = VD	IV-VC	5 8 10	0.21 0.32 0.38	£533 £533 £533	£2,538 £1,666 £1,403
A = IA B = IIB C = IIID D = IVB E = VD	IVC-D	5 8 10	0.28 0.41 0.49	£533 £533 £533	£1,904 £1,300 £1,088
A = IA B = IIB C = IIID D = IVB E = VD	III-VC-D	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772



A = IA B = IIB C = IIID D = IVB E = VD	IV-VC-D	5 8 10	0.52 0.78 0.93	£533 £533 £533	£1,025 £683 £573
A = IA B = IIB C = IIID D = IVB E = VD	VC-D	5 8 10	0.74 1.10 1.31	£533 £533 £533	£720 £485 £407
A = IA B = IIB C = IIID D = IVB E = VD	VD	5 8 10	1.17 1.75 2.08	£533 £533 £533	£456 £305 £256
A = IA B = IIB C = IVC D = VB-C E = VD	IVC	5 8 10	0.12 0.18 0.22	£533 £533 £533	£4,442 £2,961 £2,423
A = IA B = IIB C = IVC D = VB-C E = VD	IV-VC	5 8 10	0.21 0.32 0.38	£533 £533 £533	£2,538 £1,666 £1,403
A = IA B = IIB C = IVC D = VB-C E = VD	IVC-D	5 8 10	0.28 0.41 0.49	£533 £533 £533	£1,904 £1,300 £1,088
A = IA B = IIB C = IVC D = VB-C E = VD	III-VC-D	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIB C = IVC D = VB-C E = VD	IV-VC-D	5 8 10	0.52 0.78 0.93	£533 £533 £533	£1,025 £683 £573
A = IA B = IIB C = IVC D = VB-C E = VD	VC-D	5 8 10	0.74 1.10 1.31	£533 £533 £533	£720 £485 £407

A = IA B = IIIB C = IVC D = VB-C E = VD	VD	5 8 10	1.17 1.75 2.08	£533 £533 £533	£456 £305 £256
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IVC	5 8 10	0.12 0.18 0.22	£533 £533 £533	£4,442 £2,961 £2,423
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IV-VC	5 8 10	0.21 0.32 0.38	£533 £533 £533	£2,538 £1,666 £1,403
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IVC-D	5 8 10	0.28 0.41 0.49	£533 £533 £533	£1,904 £1,300 £1,088
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	III-VC-D	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IV-VC-D	5 8 10	0.52 0.78 0.93	£533 £533 £533	£1,025 £683 £573
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	VC-D	5 8 10	0.74 1.10 1.31	£533 £533 £533	£720 £485 £407
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	VD	5 8 10	1.17 1.75 2.08	£533 £533 £533	£456 £305 £256
A = IA B = IIB C = IV-VC-D D = IVB E = VD	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767

A = IA B = IIB C = IV-VC-D D = IVB E = VD	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = IIB C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IA B = IIB C = IV-VC-D D = IVB E = VD	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IA B = IIB C = IV-VC-D D = IVB E = VD	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIB C = IV-VC-D D = IVB E = VD	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = IIB C = IV-VC-D D = IVB E = VD	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IA B = IIC C = III-VC-D D = IVB E = VD	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IA B = IIC C = III-VC-D D = IVB E = VD	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719

A = IA B = IIC C = III-VC-D D = IVB E = VD	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IA B = IIC C = III-VC-D D = IVB E = VD	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = IIC C = III-VC-D D = IVB E = VD	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772

A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = IIIB-C C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265

A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	IIIC	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	IIIC-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665

A = IB B = II-B-C C = III-B-C D = IV-VC E = VIC-D	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IB B = II-B-C C = III-B-C D = IV-VC E = VIC-D	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159
A = IB B = II-B-C C = III-B-C D = IV-VC E = VIC-D	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IB B = II-B-C C = III-B-C D = IV-VC E = VIC-D	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IB B = II-B-C C = III-B-C D = IV-VC E = VIC-D	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IA B = II-III-A-B C = IV-VC-D D = IVB-C E = VC-D	III-C	5 8 10	0.02 0.03 0.03	£533 £533 £533	£26,650 £17,767 £17,767
A = IA B = II-III-A-B C = IV-VC-D D = IVB-C E = VC-D	III-C-D	5 8 10	0.11 0.17 0.20	£533 £533 £533	£4,845 £3,135 £2,665
A = IA B = II-III-A-B C = IV-VC-D D = IVB-C E = VC-D	III-IVC-D	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IA B = II-III-A-B C = IV-VC-D D = IVB-C E = VC-D	VC	5 8 10	0.26 0.39 0.46	£533 £533 £533	£2,050 £1,367 £1,159

A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	IVD	5 8 10	0.39 0.58 0.69	£533 £533 £533	£1,367 £919 £772
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	III-VD	5 8 10	0.57 0.86 1.02	£533 £533 £533	£935 £620 £523
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10	1.13 1.68 2.01	£533 £533 £533	£472 £317 £265
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IVC	5 8 10	0.03 0.05 0.06	£533 £533 £533	£17,767 £10,660 £8,883
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IV-VC	5 8 10	0.13 0.19 0.22	£533 £533 £533	£4,100 £2,805 £2,423
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10	0.19 0.28 0.34	£533 £533 £533	£2,805 £1,904 £1,568
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	III-VC-D	5 8 10	0.30 0.45 0.54	£533 £533 £533	£1,777 £1,184 £987
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10	0.43 0.65 0.77	£533 £533 £533	£1,240 £820 £692
A = IA B = IIIC C = IV-VC-D D = IVB E = VD	VC-D	5 8 10	0.65 0.97 1.16	£533 £533 £533	£820 £549 £459



A = IA B = IIIC C = IV-VC-D D = IVB E = VD	VD	5 8 10	1.08 1.62 1.93	£533 £533 £533	£494 £329 £276
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IVC	5 8 10	0.03 0.05 0.06	£533 £533 £533	£17,767 £10,660 £8,883
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VC	5 8 10	0.13 0.19 0.22	£533 £533 £533	£4,100 £2,805 £2,423
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10	0.19 0.28 0.34	£533 £533 £533	£2,805 £1,904 £1,568
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-VC-D	5 8 10	0.30 0.45 0.54	£533 £533 £533	£1,777 £1,184 £987
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10	0.43 0.65 0.77	£533 £533 £533	£1,240 £820 £692
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VC-D	5 8 10	0.65 0.97 1.16	£533 £533 £533	£820 £549 £459
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VD	5 8 10	1.08 1.62 1.93	£533 £533 £533	£494 £329 £276
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IVC	5 8 10	0.03 0.05 0.06	£533 £533 £533	£17,767 £10,660 £8,883

A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IV-VC	5 8 10	0.13 0.19 0.22	£533 £533 £533	£4,100 £2,805 £2,423
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IVC-D	5 8 10	0.19 0.28 0.34	£533 £533 £533	£2,805 £1,904 £1,568
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	III-VC-D	5 8 10	0.30 0.45 0.54	£533 £533 £533	£1,777 £1,184 £987
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IV-VC-D	5 8 10	0.43 0.65 0.77	£533 £533 £533	£1,240 £820 £692
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	VC-D	5 8 10	0.65 0.97 1.16	£533 £533 £533	£820 £549 £459
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	VD	5 8 10	1.08 1.62 1.93	£533 £533 £533	£494 £329 £276
A = IB B = III B-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VC	5 8 10	0.04 0.06 0.07	£533 £533 £533	£13,325 £8,883 £7,614
A = IB B = III B-C C = VC-D D = V-VIB-C E = V-VIC-D	IVC-D	5 8 10	0.10 0.16 0.19	£533 £533 £533	£5,330 £3,331 £2,805
A = IB B = III B-C C = VC-D D = V-VIB-C E = V-VIC-D	III-VC-D	5 8 10	0.22 0.32 0.39	£533 £533 £533	£2,423 £1,666 £1,367

A = IB B = IIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VC-D	5 8 10	0.35 0.52 0.62	£533 £533 £533	£1,523 £1,025 £860
A = IB B = IIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VD	5 8 10	0.63 0.94 1.12	£533 £533 £533	£846 £567 £476
A = IB B = IIB C = VD D = IVB E = V-VIC-D	VC	5 8 10	0.04 0.06 0.08	£533 £533 £533	£13,325 £8,883 £6,663
A = IB B = IIB C = VD D = IVB E = V-VIC-D	IVD	5 8 10	0.17 0.26 0.31	£533 £533 £533	£3,135 £2,050 £1,719
A = IB B = IIB C = VD D = IVB E = V-VIC-D	III-VD	5 8 10	0.36 0.53 0.64	£533 £533 £533	£1,481 £1,006 £833
A = IB B = IIB C = VD D = IVB E = V-VIC-D	VD	5 8 10	0.91 1.36 1.62	£533 £533 £533	£586 £392 £329
A = IB B = IIC C = VD D = VIC E = VID	IVD	5 8 10	0.04 0.06 0.08	£533 £533 £533	£13,325 £8,883 £6,663
A = IB B = IIC C = VD D = VIC E = VID	VC-D	5 8 10	0.35 0.52 0.62	£533 £533 £533	£1,523 £1,025 £860
A = IB B = IIC C = VD D = VIC E = VID	VD	5 8 10	0.78 1.16 1.39	£533 £533 £533	£683 £459 £383

## COFIELD (1984) - POST-TRAUMATIC ARTHRITIS

Conversion of Full Exercise Programme Categories into Rosser Categories - Postoperative	Sensitivity Analysis of Preoperative Rosser Categories	Duration of Joint (Years)	QALY's Gained per Patient-Discounted at 5%	Total Costs	Cost per QALY
A = IA B = IB C = IIIB D = IIIA E = IVB	IIIC	5 8 10 15	0.15 0.22 0.26 0.35	£533 £533 £533 £533	£3,553 £2,423 £2,050 £1,523
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC	5 8 10 15	0.18 0.26 0.32 0.43	£533 £533 £533 £533	£2,961 £2,050 £1,666 £1,240
A = IA B = IB C = IIIB D = IIIA E = IVB	IVC	5 8 10 15	0.21 0.31 0.37 0.50	£533 £533 £533 £533	£2,538 £1,719 £1,441 £1,066
A = IA B = IB C = IIIB D = IIIA E = IVB	IIIC-D	5 8 10 15	0.24 0.36 0.43 0.58	£533 £533 £533 £533	£2,221 £1,481 £1,240 £919
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC	5 8 10 15	0.25 0.37 0.44 0.60	£533 £533 £533 £533	£2,132 £1,441 £1,211 £888
A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VC	5 8 10 15	0.30 0.45 0.53 0.72	£533 £533 £533 £533	£1,777 £1,184 £1,006 £740
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730

A = IA B = IB C = IIIB D = IIIA E = IVB	IID	5 8 10 15	0.34 0.50 0.60 0.81	£533 £533 £533 £533	£1,568 £1,066 £888 £658
A = IA B = IB C = IIIB D = IIIA E = IVB	IVC-D	5 8 10 15	0.36 0.54 0.65 0.87	£533 £533 £533 £533	£1,481 £987 £820 £613
A = IA B = IB C = IIIB D = IIIA E = IVB	VC	5 8 10 15	0.39 0.58 0.69 0.93	£533 £533 £533 £533	£1,367 £919 £772 £573
A = IA B = IB C = IIIB D = IIIA E = IVB	III-IVD	5 8 10 15	0.43 0.64 0.76 1.03	£533 £533 £533 £533	£1,240 £833 £701 £517
A = IA B = IB C = IIIB D = IIIA E = IVB	III-VC-D	5 8 10 15	0.48 0.71 0.85 1.14	£533 £533 £533 £533	£1,110 £751 £627 £468
A = IA B = IB C = IIIB D = IIIA E = IVB	IVD	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VC-D	5 8 10 15	0.59 0.89 1.06 1.42	£533 £533 £533 £533	£903 £599 £503 £375
A = IA B = IB C = IIIB D = IIIA E = IVB	III-VD	5 8 10 15	0.70 1.05 1.26 1.69	£533 £533 £533 £533	£761 £508 £423 £315
A = IA B = IB C = IIIB D = IIIA E = IVB	VC-D	5 8 10 15	0.82 1.23 1.47 1.97	£533 £533 £533 £533	£650 £433 £363 £271

A = IA B = IB C = IIIB D = IIIA E = IVB	IV-VD	5 8 10 15	0.89 1.32 1.58 2.13	£533 £533 £533 £533	£599 £404 £337 £250
A = IA B = IB C = IIIB D = IIIA E = IVB	VD	5 8 10 15	1.26 1.87 2.24 3.01	£533 £533 £533 £533	£423 £285 £238 £177
A = IA B = IIB C = IIIB D = IVB E = VD	III-IVC	5 8 10 15	0.13 0.20 0.24 0.32	£533 £533 £533 £533	£4,100 £2,665 £2,221 £1,666
A = IA B = IIB C = IIIB D = IVB E = VD	III-VC	5 8 10 15	0.20 0.31 0.37 0.49	£533 £533 £533 £533	£2,665 £1,719 £1,441 £1,088
A = IA B = IIB C = IIIB D = IVB E = VD	IIID	5 8 10 15	0.29 0.44 0.53 0.71	£533 £533 £533 £533	£1,838 £1,211 £1,006 £751
A = IA B = IIB C = IIIB D = IVB E = VD	III-IVD	5 8 10 15	0.39 0.58 0.69 0.92	£533 £533 £533 £533	£1,367 £919 £772 £579
A = IA B = IIB C = IIIB D = IVB E = VD	IV-VC-D	5 8 10 15	0.55 0.82 0.98 1.32	£533 £533 £533 £533	£969 £650 £544 £404
A = IA B = IIB C = IIIB D = IVB E = VD	VC-D	5 8 10 15	0.78 1.16 1.39 1.87	£533 £533 £533 £533	£683 £459 £383 £285
A = IA B = IIB C = IIIB D = IVB E = VD	VD	5 8 10 15	1.21 1.81 2.16 2.91	£533 £533 £533 £533	£440 £294 £247 £183

A = IA B = IIB C = IVC D = IIIC E = VC	III-IVC	5 8 10 15	0.13 0.20 0.24 0.32	£533 £533 £533 £533	£4,100 £2,665 £2,221 £1,666
A = IA B = IIB C = IVC D = IIIC E = VC	III-VC	5 8 10 15	0.20 0.31 0.37 0.49	£533 £533 £533 £533	£2,665 £1,719 £1,441 £1,088
A = IA B = IIB C = IVC D = IIIC E = VC	IIID	5 8 10 15	0.29 0.44 0.53 0.71	£533 £533 £533 £533	£1,838 £1,211 £1,006 £751
A = IA B = IIB C = IVC D = IIIC E = VC	III-IVD	5 8 10 15	0.39 0.58 0.69 0.92	£533 £533 £533 £533	£1,367 £919 £772 £579
A = IA B = IIB C = IVC D = IIIC E = VC	IV-VC-D	5 8 10 15	0.55 0.82 0.98 1.32	£533 £533 £533 £533	£969 £650 £544 £404
A = IA B = IIB C = IVC D = IIIC E = VC	VC-D	5 8 10 15	0.78 1.16 1.39 1.87	£533 £533 £533 £533	£683 £459 £383 £285
A = IA B = IIB C = IVC D = IIIC E = VC	VD	5 8 10 15	1.21 1.81 2.16 2.91	£533 £533 £533 £533	£440 £294 £247 £183
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-IVC	5 8 10 15	0.13 0.20 0.24 0.32	£533 £533 £533 £533	£4,100 £2,665 £2,221 £1,666
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-VC	5 8 10 15	0.20 0.31 0.37 0.49	£533 £533 £533 £533	£2,665 £1,719 £1,441 £1,088

A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III D	5 8 10 15	0.29 0.44 0.53 0.71	£533 £533 £533 £533	£1,838 £1,211 £1,006 £751
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	III-IV D	5 8 10 15	0.39 0.58 0.69 0.92	£533 £533 £533 £533	£1,367 £919 £772 £579
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	IV-VC-D	5 8 10 15	0.55 0.82 0.98 1.32	£533 £533 £533 £533	£969 £650 £544 £404
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VC-D	5 8 10 15	0.78 1.16 1.39 1.87	£533 £533 £533 £533	£683 £459 £383 £285
A = IA B = II-III A C = IIIB-C D = IVB-C E = VC	VD	5 8 10 15	1.21 1.81 2.16 2.91	£533 £533 £533 £533	£440 £294 £247 £183
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	III-IV C	5 8 10 15	0.13 0.20 0.24 0.32	£533 £533 £533 £533	£4,100 £2,665 £2,221 £1,666
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	III-VC	5 8 10 15	0.20 0.31 0.37 0.49	£533 £533 £533 £533	£2,665 £1,719 £1,441 £1,088
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	III D	5 8 10 15	0.29 0.44 0.53 0.71	£533 £533 £533 £533	£1,838 £1,211 £1,006 £751
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	III-IV D	5 8 10 15	0.39 0.58 0.69 0.92	£533 £533 £533 £533	£1,367 £919 £772 £579



A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	IV-VC-D	5 8 10 15	0.55 0.82 0.98 1.32	£533 £533 £533 £533	£969 £650 £544 £404
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	VC-D	5 8 10 15	0.78 1.16 1.39 1.87	£533 £533 £533 £533	£683 £459 £383 £285
A = IB B = IIB-C C = IIIB-C D = IV-VC E = VIC-D	VD	5 8 10 15	1.21 1.81 2.16 2.91	£533 £533 £533 £533	£440 £294 £247 £183
A = IA B = IIB C = IIID D = IVB E = VD	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = IIB C = IIID D = IVB E = VD	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = IIB C = IIID D = IVB E = VD	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367
A = IA B = IIB C = IIID D = IVB E = VD	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIB C = IIID D = IVB E = VD	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808
A = IA B = IIB C = IIID D = IVB E = VD	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650

A = IA B = IIB C = IIID D = IVB E = VD	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513
A = IA B = IIB C = IIID D = IVB E = VD	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IIB C = IIID D = IVB E = VD	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IA B = IIB C = IIID D = IVB E = VD	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IA B = IIB C = IVC D = VB-C E = VD	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = IIB C = IVC D = VB-C E = VD	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = IIB C = IVC D = VB-C E = VD	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367
A = IA B = IIB C = IVC D = VB-C E = VD	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIB C = IVC D = VB-C E = VD	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808

A = IA B = IIIB C = IVC D = VB-C E = VD	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650
A = IA B = IIIB C = IVC D = VB-C E = VD	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513
A = IA B = IIIB C = IVC D = VB-C E = VD	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = IIIB C = IVC D = VB-C E = VD	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IA B = IIIB C = IVC D = VB-C E = VD	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025

A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IB B = IIIB C = IVC D = IV-VB-C E = VC-D	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	III-VC	5 8 10 15	0.16 0.24 0.29 0.39	£533 £533 £533 £533	£3,331 £2,221 £1,838 £1,367

A = IA B = II-III B C = IVC D = V-VIB-C E = VID	III-IVC-D	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IVC-D	5 8 10 15	0.28 0.41 0.49 0.66	£533 £533 £533 £533	£1,904 £1,300 £1,088 £808
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	III-IVD	5 8 10 15	0.34 0.51 0.61 0.82	£533 £533 £533 £533	£1,568 £1,045 £874 £650
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IVD	5 8 10 15	0.43 0.65 0.77 1.04	£533 £533 £533 £533	£1,240 £820 £692 £513
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	IV-VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	VC-D	5 8 10 15	0.74 1.10 1.31 1.76	£533 £533 £533 £533	£720 £485 £407 £303
A = IA B = II-III B C = IVC D = V-VIB-C E = VID	VD	5 8 10 15	1.17 1.75 2.08 2.80	£533 £533 £533 £533	£456 £305 £256 £190
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IIIC	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IA B = IIC C = IVB-C D = VB-C E = VIC-D	IVC	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838

A = IA	III-VC	5	0.16	£533	£3,331
B = IC		8	0.24	£533	£2,221
C = IVB-C		10	0.29	£533	£1,838
D = VB-C		15	0.39	£533	£1,367
E = VIC-D					
A = IA	III-IVC-D	5	0.22	£533	£2,423
B = IC		8	0.32	£533	£1,666
C = IVB-C		10	0.39	£533	£1,367
D = VB-C		15	0.52	£533	£1,025
E = VIC-D					
A = IA	IVC-D	5	0.28	£533	£1,904
B = IC		8	0.41	£533	£1,300
C = IVB-C		10	0.49	£533	£1,088
D = VB-C		15	0.66	£533	£808
E = VIC-D					
A = IA	III-IVD	5	0.34	£533	£1,568
B = IC		8	0.51	£533	£1,045
C = IVB-C		10	0.61	£533	£874
D = VB-C		15	0.82	£533	£650
E = VIC-D					
A = IA	IVD	5	0.43	£533	£1,240
B = IC		8	0.65	£533	£820
C = IVB-C		10	0.77	£533	£692
D = VB-C		15	1.04	£533	£513
E = VIC-D					
A = IA	IV-VC-D	5	0.52	£533	£1,025
B = IC		8	0.78	£533	£683
C = IVB-C		10	0.93	£533	£573
D = VB-C		15	1.25	£533	£426
E = VIC-D					
A = IA	VC-D	5	0.74	£533	£720
B = IC		8	1.10	£533	£485
C = IVB-C		10	1.31	£533	£407
D = VB-C		15	1.76	£533	£303
E = VIC-D					
A = IA	VD	5	1.17	£533	£456
B = IC		8	1.75	£533	£305
C = IVB-C		10	2.08	£533	£256
D = VB-C		15	2.80	£533	£190
E = VIC-D					
A = IA	III-IVC	5	0.004	£533	£133,250
B = IB		8	0.006	£533	£88,833
C = IV-VC-D		10	0.008	£533	£66,625
D = IVB		15	0.010	£533	£53,300
E = VD					

A = IA	III-C-D	5	0.07	£533	£7,614
B = IIB		8	0.10	£533	£5,330
C = IV-VC-D		10	0.12	£533	£4,442
D = IVB		15	0.17	£533	£3,135
E = VD					
A = IA	IV-VC	5	0.13	£533	£4,100
B = IIB		8	0.19	£533	£2,805
C = IV-VC-D		10	0.22	£533	£2,423
D = IVB		15	0.30	£533	£1,777
E = VD					
A = IA	IIID	5	0.16	£533	£3,331
B = IIB		8	0.25	£533	£2,132
C = IV-VC-D		10	0.29	£533	£1,838
D = IVB		15	0.39	£533	£1,367
E = VD					
A = IA	VC	5	0.22	£533	£2,423
B = IIB		8	0.32	£533	£1,666
C = IV-VC-D		10	0.39	£533	£1,367
D = IVB		15	0.52	£533	£1,025
E = VD					
A = IA	III-VC-D	5	0.30	£533	£1,777
B = IIB		8	0.45	£533	£1,184
C = IV-VC-D		10	0.54	£533	£987
D = IVB		15	0.73	£533	£730
E = VD					
A = IA	IV-VC-D	5	0.42	£533	£1,269
B = IIB		8	0.63	£533	£846
C = IV-VC-D		10	0.75	£533	£711
D = IVB		15	1.01	£533	£528
E = VD					
A = IA	III-VD	5	0.53	£533	£1,006
B = IIB		8	0.79	£533	£675
C = IV-VC-D		10	0.95	£533	£561
D = IVB		15	1.27	£533	£420
E = VD					
A = IA	IV-VD	5	0.71	£533	£751
B = IIB		8	1.07	£533	£498
C = IV-VC-D		10	1.27	£533	£420
D = IVB		15	1.71	£533	£312
E = VD					
A = IA	VD	5	1.08	£533	£494
B = IIB		8	1.62	£533	£329
C = IV-VC-D		10	1.93	£533	£276
D = IVB		15	2.59	£533	£206
E = VD					

A = IA B = IIC C = III-VC-D D = IVB E = VD	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IA B = IIC C = III-VC-D D = IVB E = VD	IIIC-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135
A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VC	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IA B = IIC C = III-VC-D D = IVB E = VD	IIID	5 8 10 15	0.16 0.25 0.29 0.39	£533 £533 £533 £533	£3,331 £2,132 £1,838 £1,367
A = IA B = IIC C = III-VC-D D = IVB E = VD	VC	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.42 0.63 0.75 1.01	£533 £533 £533 £533	£1,269 £846 £711 £528
A = IA B = IIC C = III-VC-D D = IVB E = VD	III-VD	5 8 10 15	0.53 0.79 0.95 1.27	£533 £533 £533 £533	£1,006 £675 £561 £420
A = IA B = IIC C = III-VC-D D = IVB E = VD	IV-VD	5 8 10 15	0.71 1.07 1.27 1.71	£533 £533 £533 £533	£751 £498 £420 £312



A = IA B = IIC C = III-VC-D D = IVB E = VD	VD	5 8 10 15	1.08 1.62 1.93 2.59	£533 £533 £533 £533	£494 £329 £276 £206
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IIIC-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IV-VC	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IIID	5 8 10 15	0.16 0.25 0.29 0.39	£533 £533 £533 £533	£3,331 £2,132 £1,838 £1,367
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VC	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.42 0.63 0.75 1.01	£533 £533 £533 £533	£1,269 £846 £711 £528
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	III-VD	5 8 10 15	0.53 0.79 0.95 1.27	£533 £533 £533 £533	£1,006 £675 £561 £420

A = IA B = IIIA C = IV-VC-D D = IVB E = VD	IV-VD	5 8 10 15	0.71 1.07 1.27 1.71	£533 £533 £533 £533	£751 £498 £420 £312
A = IA B = IIIA C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.08 1.62 1.93 2.59	£533 £533 £533 £533	£494 £329 £276 £206
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	III-IVC	5 8 10 15	0.004 0.006 0.008 0.010	£533 £533 £533 £533	£133,250 £88,833 £66,625 £53,300
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	IIIC-D	5 8 10 15	0.07 0.10 0.12 0.17	£533 £533 £533 £533	£7,614 £5,330 £4,442 £3,135
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	IV-VC	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	IIID	5 8 10 15	0.16 0.25 0.29 0.39	£533 £533 £533 £533	£3,331 £2,132 £1,838 £1,367
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	VC	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	III-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IA B = II-IIIA-B C = IV-VC-D D = IVB-C E = VC-D	IV-VC-D	5 8 10 15	0.42 0.63 0.75 1.01	£533 £533 £533 £533	£1,269 £846 £711 £528

A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	III-VD	5 8 10 15	0.53 0.79 0.95 1.27	£533 £533 £533 £533	£1,006 £675 £561 £420
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	IV-VD	5 8 10 15	0.71 1.07 1.27 1.71	£533 £533 £533 £533	£751 £498 £420 £312
A = IA B = II-III A-B C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10 15	1.08 1.62 1.93 2.59	£533 £533 £533 £533	£494 £329 £276 £206
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-C-D	5 8 10 15	0.03 0.04 0.05 0.06	£533 £533 £533 £533	£17,767 £13,325 £10,660 £8,883
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VC	5 8 10 15	0.08 0.12 0.15 0.20	£533 £533 £533 £533	£6,663 £4,442 £3,553 £2,665
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III D	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VC	5 8 10 15	0.17 0.26 0.31 0.42	£533 £533 £533 £533	£3,135 £2,050 £1,719 £1,269
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-VC-D	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.38 0.56 0.67 0.90	£533 £533 £533 £533	£1,403 £952 £796 £592

A = IB B = II-III B C = IV-VC-D D = IVB E = VD	III-VD	5 8 10 15	0.49 0.73 0.87 1.17	£533 £533 £533 £533	£1,088 £730 £613 £456
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	IV-VD	5 8 10 15	0.67 1.00 1.20 1.61	£533 £533 £533 £533	£796 £533 £444 £331
A = IB B = II-III B C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.04 1.55 1.85 2.49	£533 £533 £533 £533	£513 £344 £288 £214
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III C-D	5 8 10 15	0.03 0.04 0.05 0.06	£533 £533 £533 £533	£17,767 £13,325 £10,660 £8,883
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IV-VC	5 8 10 15	0.08 0.12 0.15 0.20	£533 £533 £533 £533	£6,663 £4,442 £3,553 £2,665
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III D	5 8 10 15	0.12 0.18 0.22 0.29	£533 £533 £533 £533	£4,442 £2,961 £2,423 £1,838
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	VC	5 8 10 15	0.17 0.26 0.31 0.42	£533 £533 £533 £533	£3,135 £2,050 £1,719 £1,269
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III-VC-D	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IV-VC-D	5 8 10 15	0.38 0.56 0.67 0.90	£533 £533 £533 £533	£1,403 £952 £796 £592

A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	III-VD	5 8 10 15	0.49 0.73 0.87 1.17	£533 £533 £533 £533	£1,088 £730 £613 £456
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	IV-VD	5 8 10 15	0.67 1.00 1.20 1.61	£533 £533 £533 £533	£796 £533 £444 £331
A = IA B = III B-C C = IV-VC-D D = IVB-C E = VC-D	VD	5 8 10 15	1.04 1.55 1.85 2.49	£533 £533 £533 £533	£513 £344 £288 £214
A = IA B = III C C = IV-VC-D D = IVB E = VD	III-IVC-D	5 8 10 15	0.04 0.06 0.08 0.10	£533 £533 £533 £533	£13,325 £8,883 £6,663 £5,330
A = IA B = III C C = IV-VC-D D = IVB E = VD	IVC-D	5 8 10 15	0.10 0.16 0.19 0.25	£533 £533 £533 £533	£5,330 £3,331 £2,805 £2,132
A = IA B = III C C = IV-VC-D D = IVB E = VD	III-IVD	5 8 10 15	0.17 0.25 0.30 0.40	£533 £533 £533 £533	£3,135 £2,132 £1,777 £1,333
A = IA B = III C C = IV-VC-D D = IVB E = VD	IVD	5 8 10 15	0.26 0.39 0.46 0.62	£533 £533 £533 £533	£2,050 £1,367 £1,159 £860
A = IA B = III C C = IV-VC-D D = IVB E = VD	IV-VC-D	5 8 10 15	0.35 0.52 0.62 0.83	£533 £533 £533 £533	£1,523 £1,025 £860 £642
A = IA B = III C C = IV-VC-D D = IVB E = VD	VC-D	5 8 10 15	0.56 0.84 1.00 1.35	£533 £533 £533 £533	£952 £635 £533 £395

A = IA B = IIIC C = IV-VC-D D = IVB E = VD	VD	5 8 10 15	1.00 1.49 1.78 2.39	£533 £533 £533 £533	£533 £358 £299 £223
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IVC-D	5 8 10 15	0.06 0.09 0.11 0.15	£533 £533 £533 £533	£8,883 £5,922 £4,845 £3,553
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	III-IVD	5 8 10 15	0.13 0.19 0.22 0.30	£533 £533 £533 £533	£4,100 £2,805 £2,423 £1,777
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IVD	5 8 10 15	0.22 0.32 0.39 0.52	£533 £533 £533 £533	£2,423 £1,666 £1,367 £1,025
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	IV-VC-D	5 8 10 15	0.30 0.45 0.54 0.73	£533 £533 £533 £533	£1,777 £1,184 £987 £730
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	VC-D	5 8 10 15	0.52 0.78 0.93 1.25	£533 £533 £533 £533	£1,025 £683 £573 £426
A = IB B = IIIB-C C = VC-D D = V-VIB-C E = V-VIC-D	VD	5 8 10 15	0.95 1.42 1.70 2.28	£533 £533 £533 £533	£561 £375 £314 £234
A = IB B = IIB C = VD D = IVB E = V-VIC-D	III-IVD	5 8 10 15	0.04 0.06 0.07 0.09	£533 £533 £533 £533	£13,325 £8,883 £7,614 £5,922
A = IB B = IIB C = VD D = IVB E = V-VIC-D	IVD	5 8 10 15	0.13 0.19 0.23 0.31	£533 £533 £533 £533	£4,100 £2,805 £2,317 £1,719

A = IB	IV-VC-D	5	0.22	£533	£2,423
B = IIB		8	0.32	£533	£1,666
C = VD		10	0.39	£533	£1,367
D = IVB		15	0.52	£533	£1,025
E = V-VIC-D					
A = IB	VC-D	5	0.43	£533	£1,240
B = IIB		8	0.65	£533	£820
C = VD		10	0.77	£533	£692
D = IVB		15	1.04	£533	£513
E = V-VIC-D					
A = IB	IV-VD	5	0.50	£533	£1,066
B = IIB		8	0.74	£533	£720
C = VD		10	0.89	£533	£599
D = IVB		15	1.19	£533	£448
E = V-VIC-D					
A = IB	VD	5	0.87	£533	£613
B = IIB		8	1.29	£533	£413
C = VD		10	1.54	£533	£346
D = IVB		15	2.08	£533	£256
E = V-VIC-D					
A = IB	III-VC-D	5	0.04	£533	£13,325
B = IIIC		8	0.06	£533	£8,883
C = VD		10	0.08	£533	£6,663
D = VIC		15	0.10	£533	£5,330
E = VID					
A = IB	IV-VC-D	5	0.16	£533	£3,331
B = IIIC		8	0.24	£533	£2,221
C = VD		10	0.29	£533	£1,838
D = VIC		15	0.38	£533	£1,403
E = VID					
A = IB	III-VD	5	0.27	£533	£1,974
B = IIIC		8	0.41	£533	£1,300
C = VD		10	0.48	£533	£1,110
D = VIC		15	0.65	£533	£820
E = VID					
A = IB	IV-VD	5	0.45	£533	£1,184
B = IIIC		8	0.68	£533	£784
C = VD		10	0.81	£533	£658
D = VIC		15	1.09	£533	£489
E = VID					
A = IB	VD	5	0.82	£533	£650
B = IIIC		8	1.23	£533	£433
C = VD		10	1.47	£533	£363
D = VIC		15	1.97	£533	£271
E = VID					

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF ELBOW JOINT REPLACEMENT  
SURGERY DATA  
SONI AND CAVENDISH (1984)**

Conversion of Function Categories into Rosser Disability Categories - Preoperative	Conversion of Function Categories into Rosser Disability Categories - Postoperative	Duration of Joint (Years)	QALY's Gained per Patient- Discounted at 5%	Total Costs	Cost per QALY
A = I B = II C-D = III	A = I B = II C = III D = IV	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I B = II C-D = III-IV	A = I B = II C = III D = IV	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I-II B = III C-D = IV	A = I B = II C = III D = IV	5 8	0.35 0.52	£533 £533	£1,523 £1,025
A = I B = II C-D = III-V	A = I B = II C = III D = IV	5 8	0.48 0.71	£533 £533	£1,110 £751
A = I-II B = III-IV C-D = V	A = I B = II C = III D = IV	5 8	0.82 1.23	£533 £533	£650 £433
A = I B = II C-D = III-VI	A = I B = II C = III D = IV	5 8	1.08 1.62	£533 £533	£494 £329
A = I-II B = III C-D = IV-VI	A = I B = II C = III D = IV	5 8	1.34 2.00	£533 £533	£398 £267
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III D = IV	5 8	1.82 2.71	£533 £533	£293 £197
A = I B = II C-D = III	A = I B = II C = III D = IV-V	5 8	0.22 0.32	£533 £533	£2,423 £1,666



A = I B = II C-D = III-IV	A = I B = II C = III D = IV-V	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I-II B = III C-D = IV	A = I B = II C = III D = IV-V	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I B = II C-D = III-V	A = I B = II C = III D = IV-V	5 8	0.43 0.65	£533 £533	£1,240 £820
A = I-II B = III-IV C-D = V	A = I B = II C = III D = IV-V	5 8	0.78 1.16	£533 £533	£683 £459
A = I B = II C-D = III-VI	A = I B = II C = III D = IV-V	5 8	1.04 1.55	£533 £533	£513 £344
A = I-II B = III C-D = IV-VI	A = I B = II C = III D = IV-V	5 8	1.30 1.94	£533 £533	£410 £275
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III D = IV-V	5 8	1.78 2.65	£533 £533	£299 £201
A = I B = II C-D = III	A = I B = II C = III D = IV-VI	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I B = II C-D = III-IV	A = I B = II C = III D = IV-VI	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I-II B = III C-D = IV	A = I B = II C = III D = IV-VI	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I B = II C-D = III-V	A = I B = II C = III D = IV-VI	5 8	0.43 0.65	£533 £533	£1,240 £820
A = I-II B = III-IV C-D = V	A = I B = II C = III D = IV-VI	5 8	0.78 1.16	£533 £533	£683 £459

A = I B = II C-D = III-VI	A = I B = II C = III D = IV-VI	5 8	1.04 1.55	£533 £533	£513 £344
A = I-II B = III C-D = IV-VI	A = I B = II C = III D = IV-VI	5 8	1.30 1.94	£533 £533	£410 £275
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III D = IV-VI	5 8	1.78 2.65	£533 £533	£299 £201
A = I B = II C-D = III	A = I B = II-III C = IV D = V	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I B = II C-D = III-IV	A = I B = II-III C = IV D = V	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I-II B = III C-D = IV	A = I B = II-III C = IV D = V	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I B = II C-D = III-V	A = I B = II-III C = IV D = V	5 8	0.43 0.65	£533 £533	£1,240 £820
A = I-II B = III-IV C-D = V	A = I B = II-III C = IV D = V	5 8	0.78 1.16	£533 £533	£683 £459
A = I B = II C-D = III-VI	A = I B = II-III C = IV D = V	5 8	1.04 1.55	£533 £533	£513 £344
A = I-II B = III C-D = IV-VI	A = I B = II-III C = IV D = V	5 8	1.30 1.94	£533 £533	£410 £275
A = I-II B = III-IV C-D = V-VI	A = I B = II-III C = IV D = V	5 8	1.78 2.65	£533 £533	£299 £201
A = I B = II C-D = III	A = I B = II C = III-IV D = V	5 8	0.22 0.32	£533 £533	£2,423 £1,666

A = I B = II C-D = III-IV	A = I B = II C = III-IV D = V	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I-II B = III C-D = IV	A = I B = II C = III-IV D = V	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I B = II C-D = III-V	A = I B = II C = III-IV D = V	5 8	0.43 0.65	£533 £533	£1,240 £820
A = I-II B = III-IV C-D = V	A = I B = II C = III-IV D = V	5 8	0.78 1.16	£533 £533	£683 £459
A = I B = II C-D = III-VI	A = I B = II C = III-IV D = V	5 8	1.04 1.55	£533 £533	£513 £344
A = I-II B = III C-D = IV-VI	A = I B = II C = III-IV D = V	5 8	1.30 1.94	£533 £533	£410 £275
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III-IV D = V	5 8	1.78 2.65	£533 £533	£299 £201
A = I B = II C-D = III	A = I B = II-III C = IV D = V-VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I B = II C-D = III-IV	A = I B = II-III C = IV D = V-VI	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I-II B = III C-D = IV	A = I B = II-III C = IV D = V-VI	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I B = II C-D = III-V	A = I B = II-III C = IV D = V-VI	5 8	0.39 0.58	£533 £533	£1,367 £919
A = I-II B = III-IV C-D = V	A = I B = II-III C = IV D = V-VI	5 8	0.74 1.10	£533 £533	£720 £485

A = I B = II C-D = III-VI	A = I B = II-III C = IV D = V-VI	5 8	1.00 1.49	£533 £533	£533 £358
A = I-II B = III C-D = IV-VI	A = I B = II-III C = IV D = V-VI	5 8	1.26 1.87	£533 £533	£423 £285
A = I-II B = III-IV C-D = V-VI	A = I B = II-III C = IV D = V-VI	5 8	1.73 2.59	£533 £533	£308 £206
A = I B = II C-D = III	A = I B = II C = III-IV D = V-VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I B = II C-D = III-IV	A = I B = II C = III-IV D = V-VI	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I-II B = III C-D = IV	A = I B = II C = III-IV D = V-VI	5 8	0.26 0.39	£533 £533	£2,050 £1,367
A = I B = II C-D = III-V	A = I B = II C = III-IV D = V-VI	5 8	0.39 0.58	£533 £533	£1,367 £919
A = I-II B = III-IV C-D = V	A = I B = II C = III-IV D = V-VI	5 8	0.74 1.10	£533 £533	£720 £485
A = I B = II C-D = III-VI	A = I B = II C = III-IV D = V-VI	5 8	1.00 1.49	£533 £533	£533 £358
A = I-II B = III C-D = IV-VI	A = I B = II C = III-IV D = V-VI	5 8	1.26 1.87	£533 £533	£423 £285
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III-IV D = V-VI	5 8	1.73 2.59	£533 £533	£308 £206
A = I B = II C-D = III	A = I B = II C = III-V D = VI	5 8	0.13 0.19	£533 £533	£4,100 £2,805

A = I B = II C-D = III-IV	A = I B = II C = III-V D = VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I-II B = III C-D = IV	A = I B = II C = III-V D = VI	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I B = II C-D = III-V	A = I B = II C = III-V D = VI	5 8	0.35 0.52	£533 £533	£1,523 £1,025
A = I-II B = III-IV C-D = V	A = I B = II C = III-V D = VI	5 8	0.69 1.03	£533 £533	£772 £517
A = I B = II C-D = III-VI	A = I B = II C = III-V D = VI	5 8	0.95 1.42	£533 £533	£561 £375
A = I-II B = III C-D = IV-VI	A = I B = II C = III-V D = VI	5 8	1.21 1.81	£533 £533	£440 £294
A = I-II B = III-IV C-D = V-VI	A = I B = II C = III-V D = VI	5 8	1.69 2.52	£533 £533	£315 £212
A = I B = II C-D = III	A = I-II B = III C = IV D = V-VI	5 8	0.13 0.19	£533 £533	£4,100 £2,805
A = I B = II C-D = III-IV	A = I-II B = III C = IV D = V-VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I-II B = III C-D = IV	A = I-II B = III C = IV D = V-VI	5 8	0.22 0.32	£533 £533	£2,423 £1,666
A = I B = II C-D = III-V	A = I-II B = III C = IV D = V-VI	5 8	0.35 0.52	£533 £533	£1,523 £1,025
A = I-II B = III-IV C-D = V	A = I-II B = III C = IV D = V-VI	5 8	0.69 1.03	£533 £533	£772 £517

A = I B = II C-D = III-VI	A = I-II B = III C = IV D = V-VI	5 8	0.95 1.42	£533 £533	£561 £375
A = I-II B = III C-D = IV-VI	A = I-II B = III C = IV D = V-VI	5 8	1.21 1.81	£533 £533	£440 £294
A = I-II B = III-IV C-D = V-VI	A = I-II B = III C = IV D = V-VI	5 8	1.69 2.52	£533 £533	£315 £212
A = I B = II C-D = III	A = I B = II-III C = IV-V D = VI	5 8	0.09 0.13	£533 £533	£5,922 £4,100
A = I B = II C-D = III-IV	A = I B = II-III C = IV-V D = VI	5 8	0.13 0.19	£533 £533	£4,100 £2,805
A = I-II B = III C-D = IV	A = I B = II-III C = IV-V D = VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I B = II C-D = III-V	A = I B = II-III C = IV-V D = VI	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I-II B = III-IV C-D = V	A = I B = II-III C = IV-V D = VI	5 8	0.65 0.97	£533 £533	£820 £549
A = I B = II C-D = III-VI	A = I B = II-III C = IV-V D = VI	5 8	0.91 1.36	£533 £533	£586 £392
A = I-II B = III C-D = IV-VI	A = I B = II-III C = IV-V D = VI	5 8	1.17 1.75	£533 £533	£456 £305
A = I-II B = III-IV C-D = V-VI	A = I B = II-III C = IV-V D = VI	5 8	1.65 2.46	£533 £533	£323 £217
A = I B = II C-D = III	A = I B = II-IV C = V D = VI	5 8	0.09 0.13	£533 £533	£5,922 £4,100

A = I B = II C-D = III-IV	A = I B = II-IV C = V D = VI	5 8	0.13 0.19	£533 £533	£4,100 £2,805
A = I-II B = III C-D = IV	A = I B = II-IV C = V D = VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I B = II C-D = III-V	A = I B = II-IV C = V D = VI	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I-II B = III-IV C-D = V	A = I B = II-IV C = V D = VI	5 8	0.65 0.97	£533 £533	£820 £549
A = I B = II C-D = III-VI	A = I B = II-IV C = V D = VI	5 8	0.91 1.36	£533 £533	£586 £392
A = I-II B = III C-D = IV-VI	A = I B = II-IV C = V D = VI	5 8	1.17 1.75	£533 £533	£456 £305
A = I-II B = III-IV C-D = V-VI	A = I B = II-IV C = V D = VI	5 8	1.65 2.46	£533 £533	£323 £217
A = I B = II C-D = III	A = I-II B = III-IV C = V D = VI	5 8	0.09 0.13	£533 £533	£5,922 £4,100
A = I B = II C-D = III-IV	A = I-II B = III-IV C = V D = VI	5 8	0.13 0.19	£533 £533	£4,100 £2,805
A = I-II B = III C-D = IV	A = I-II B = III-IV C = V D = VI	5 8	0.17 0.26	£533 £533	£3,135 £2,050
A = I B = II C-D = III-V	A = I-II B = III-IV C = V D = VI	5 8	0.30 0.45	£533 £533	£1,777 £1,184
A = I-II B = III-IV C-D = V	A = I-II B = III-IV C = V D = VI	5 8	0.65 0.97	£533 £533	£820 £549

A = I B = II C-D = III-VI	A = I-II B = III-IV C = V D = VI	5 8	0.91 1.36	£533 £533	£586 £392
A = I-II B = III C-D = IV-VI	A = I-II B = III-IV C = V D = VI	5 8	1.17 1.75	£533 £533	£456 £305
A = I-II B = III-IV C-D = V-VI	A = I-II B = III-IV C = V D = VI	5 8	1.65 2.46	£533 £533	£323 £217



**SENSITIVITY ANALYSIS OF GUDEX'S USE OF CEFTAZIDIME TREATMENT  
OF CYSTIC FIBROSIS DATA**  
**BOYLE ET AL (1976)**

Conversion of Clinical Score into Rosser Disability Categories	Conversion of Daily Coping Skills into Rosser Distress Categories - Established Treatment	Conversion of Daily Coping Skills into Rosser Distress Categories - Ceftazidime Treatment	Average Life Expectancy From Birth	QALY's Gained Over Established Treatment	Total Costs (Discounted at 5%)	Cost per QALY
76-100=I	Good=A/B	Good=A	22	0.26	£3,291	£12,658
65-75=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
45-64=III-IV	Poor=D	Poor=C	24	0.88	£3,450	£3,876
35-44=V-VI			25	1.17	£3,523	£2,986
0-34=VII						
76-100=I	Good=B	Good=A	22	0.26	£3,291	£12,658
65-75=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
45-64=III-IV	Poor=D	Poor=C	24	0.88	£3,450	£3,876
35-44=V-VI			25	1.17	£3,523	£2,986
0-34=VII						
81-100=I	Good=A/B	Good=A	22	0.26	£3,291	£12,658
70-80=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-69=III-IV	Poor=D	Poor=C	24	0.87	£3,450	£3,966
40-49=V-VI			25	1.16	£3,523	£3,037
0-39=VII						
81-100=I	Good=B	Good=A	22	0.26	£3,291	£12,658
70-80=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-69=III-IV	Poor=D	Poor=C	24	0.87	£3,450	£3,966
40-49=V-VI			25	1.16	£3,523	£3,037
0-39=VII						
81-100=I	Good=A/B	Good=A	22	0.26	£3,291	£12,658
65-80=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-64=III-IV	Poor=D	Poor=C	24	0.87	£3,450	£3,966
40-49=V-VI			25	1.16	£3,523	£3,037
0-39=VII						
81-100=I	Good=B	Good=A	22	0.26	£3,291	£12,658
65-80=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-64=III-IV	Poor=D	Poor=C	24	0.87	£3,450	£3,966
40-49=V-VI			25	1.16	£3,523	£3,037
0-39=VII						
86-100=I	Good=A/B	Good=A	22	1.18	£3,291	£2,789
75-85=II	Fair=C	Fair=B	23	1.48	£3,372	£2,278
65-74=III-IV	Poor=D	Poor=C	24	1.76	£3,450	£1,960
50-64=V-VI			25	2.02	£3,523	£1,744
0-49=VII						

86-100=I	Good=B	Good=A	22	1.18	£3,291	£2,789
75-85=II	Fair=C	Fair=B	23	1.48	£3,372	£2,278
65-74=III-IV	Poor=D	Poor=C	24	1.76	£3,450	£1,960
50-64=V-VI			25	2.02	£3,523	£1,744
0-49=VII						
86-100=I	Good=A/B	Good=A	22	0.26	£3,291	£12,658
65-85=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-64=III-IV	Poor=D	Poor=C	24	0.88	£3,450	£3,920
35-49=V-VI			25	1.17	£3,523	£3,011
0-34=VII						
86-100=I	Good=B	Good=A	22	0.26	£3,291	£12,658
65-85=II	Fair=C	Fair=B	23	0.58	£3,372	£5,814
50-64=III-IV	Poor=D	Poor=C	24	0.88	£3,450	£3,920
35-49=V-VI			25	1.17	£3,523	£3,011
0-34=VII						
91-100=I	Good=A/B	Good=A	22	0.79	£3,291	£4,166
75-90=II	Fair=C	Fair=B	23	1.09	£3,372	£3,094
60-74=III-IV	Poor=D	Poor=C	24	1.38	£3,450	£2,500
45-59=V-VI			25	1.66	£3,523	£2,122
0-44=VII						
91-100=I	Good=B	Good=A	22	0.92	£3,291	£3,577
75-90=II	Fair=C	Fair=B	23	1.22	£3,372	£2,764
60-74=III-IV	Poor=D	Poor=C	24	1.51	£3,450	£2,285
45-59=V-VI			25	1.79	£3,523	£1,968
0-44=VII						
96-100=I	Good=A/B	Good=A	22	1.32	£3,291	£2,493
85-95=II	Fair=C	Fair=B	23	1.61	£3,372	£2,094
70-84=III-IV	Poor=D	Poor=C	24	1.88	£3,450	£1,835
50-69=V-VI			25	2.14	£3,523	£1,646
0-49=VII						
96-100=I	Good=B	Good=A	22	1.45	£3,291	£2,270
85-95=II	Fair=C	Fair=B	23	1.74	£3,372	£1,938
70-84=III-IV	Poor=D	Poor=C	24	2.01	£3,450	£1,716
50-69=V-VI			25	2.28	£3,523	£1,545
0-49=VII						

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF SCOLIOSIS SURGERY FOR  
IDIOPATHIC ADOLESCENTS DATA  
VAN GROUW ET AL (1976)**

Conversion of Activity Categories into Rosser Disability Categories	Conversion of Pain Categories into Rosser Distress Categories	Life Expectancy of Untreated Patients (Years)	QALY's Gained per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
I = VI-VII II = V III = IV IV = II	1 = A 2 = B 3 = B 4 = C 5 = C 6 = D	40 50 60 70	4.28 2.30 1.09 0.34	£3,143 £3,143 £3,143 £3,143	£734 £1,367 £2,883 £9,244
I = VI II = IV III = III IV = II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.32 2.33 1.10 0.35	£3,143 £3,143 £3,143 £3,143	£728 £1,349 £2,857 £8,980
I = V-VI II = IV III = III IV = II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.37 2.35 1.11 0.35	£3,143 £3,143 £3,143 £3,143	£719 £1,337 £2,832 £8,980
I = V II = IV III = IV IV = I-II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.42 2.38 1.12 0.35	£3,143 £3,143 £3,143 £3,143	£711 £1,321 £2,806 £8,980
I = VI II = IV III = III IV = II	1 = A 2 = B 3 = B 4 = C 5 = C 6 = D	40 50 60 70	4.42 2.38 1.12 0.35	£3,143 £3,143 £3,143 £3,143	£711 £1,321 £2,806 £8,980
I = V II = III III = III IV = I-II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.46 2.40 1.14 0.36	£3,143 £3,143 £3,143 £3,143	£705 £1,310 £2,757 £8,731

I = V II = IV III = III IV = I-II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.46 2.40 1.14 0.36	£3,143 £3,143 £3,143 £3,143	£705 £1,310 £2,757 £8,731
I = V-VI II = IV III = III IV = II	1 = A 2 = B 3 = B 4 = C 5 = C 6 = D	40 50 60 70	4.46 2.40 1.14 0.36	£3,143 £3,143 £3,143 £3,143	£705 £1,310 £2,757 £8,731
I = IV II = III III = III IV = I-II	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.51 2.43 1.15 0.36	£3,143 £3,143 £3,143 £3,143	£697 £1,293 £2,733 £8,731
I = V II = IV III = III IV = I-II	1 = A 2 = B 3 = B 4 = C 5 = C 6 = D	40 50 60 70	4.51 2.43 1.15 0.36	£3,143 £3,143 £3,143 £3,143	£697 £1,293 £2,733 £8,731
I = V II = IV III = IV IV = I-II	1 = A 2 = B 3 = B 4 = C 5 = C 6 = D	40 50 60 70	4.51 2.43 1.15 0.36	£3,143 £3,143 £3,143 £3,143	£697 £1,293 £2,733 £8,731
I = III II = III III = II IV = I	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.56 2.45 1.16 0.37	£3,143 £3,143 £3,143 £3,143	£689 £1,283 £2,709 £8,495
I = IV II = III III = II IV = I	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.56 2.45 1.16 0.37	£3,143 £3,143 £3,143 £3,143	£689 £1,283 £2,709 £8,495
I = IV II = IV III = II IV = I	1 = A 2 = B 3 = C 4 = C 5 = D 6 = D	40 50 60 70	4.56 2.45 1.16 0.37	£3,143 £3,143 £3,143 £3,143	£689 £1,283 £2,709 £8,495

I = IV	1 = A	40	4.56	£3,143	£689
II = III	2 = B	50	2.45	£3,143	£1,283
III = III	3 = B	60	1.16	£3,143	£2,709
IV = I-II	4 = C	70	0.37	£3,143	£8,495
	5 = C				
	6 = D				
I = V	1 = A	40	4.56	£3,143	£689
II = III	2 = B	50	2.45	£3,143	£1,283
III = III	3 = B	60	1.16	£3,143	£2,709
IV = I-II	4 = C	70	0.37	£3,143	£8,495
	5 = C				
	6 = D				
I = III	1 = A	40	4.61	£3,143	£682
II = III	2 = B	50	2.48	£3,143	£1,267
III = II	3 = B	60	1.17	£3,143	£2,686
IV = I	4 = C	70	0.37	£3,143	£8,495
	5 = C				
	6 = D				
I = IV	1 = A	40	4.61	£3,143	£682
II = III	2 = B	50	2.48	£3,143	£1,267
III = II	3 = B	60	1.17	£3,143	£2,686
IV = I	4 = C	70	0.37	£3,143	£8,495
	5 = C				
	6 = D				
I = IV	1 = A	40	4.61	£3,143	£682
II = IV	2 = B	50	2.48	£3,143	£1,267
III = II	3 = B	60	1.17	£3,143	£2,686
IV = I	4 = C	70	0.37	£3,143	£8,495
	5 = C				
	6 = D				

**SENSITIVITY ANALYSIS OF GUDEX'S USE OF SCOLIOSIS SECONDARY TO NEUROMUSCULAR ILLNESS DATA**

Health State with Operation in terms of Rosser Disability/ Distress Categories	Health State without Operation in terms of Rosser Disability/ Distress Categories	Life Expectancy With Operation	QALY's Gained Per Patient (Discounted at 5%)	Total Costs (Discounted at 5%)	Cost per QALY
VC	VIC	30	2.38	£3,143	£1,321
		40	5.57	£3,143	£564
VC	VIC-D	30	6.07	£3,143	£518
		40	9.25	£3,143	£340
VC	VID	30	9.75	£3,143	£322
		40	12.94	£3,143	£243
VC	VI-VIIC	30	6.07	£3,143	£518
		40	9.25	£3,143	£340
VC	VI-VIIC-D	30	11.94	£3,143	£263
		40	15.12	£3,143	£208
VC	VI-VIID	30	17.81	£3,143	£176
		40	20.99	£3,143	£150
VC	VIIC	30	9.75	£3,143	£322
		40	12.94	£3,143	£243
VC	VIIC-D	30	17.81	£3,143	£176
		40	20.99	£3,143	£150
VC	VIID	30	25.86	£3,143	£122
		40	29.04	£3,143	£108
VC-D	VIC	30	1.30	£3,143	£2,418
		40	4.13	£3,143	£761
VC-D	VIC-D	30	4.99	£3,143	£630
		40	7.82	£3,143	£402
VC-D	VID	30	8.67	£3,143	£363
		40	11.50	£3,143	£273
VC-D	VI-VIIC	30	4.99	£3,143	£630
		40	7.82	£3,143	£402
VC-D	VI-VIIC-D	30	10.85	£3,143	£290
		40	13.68	£3,143	£230
VC-D	VI-VIID	30	16.72	£3,143	£188
		40	19.55	£3,143	£161
VC-D	VIIC	30	8.67	£3,143	£363
		40	11.50	£3,143	£273
VC-D	VIIC-D	30	16.72	£3,143	£188
		40	19.55	£3,143	£161

VC-D	VIID	30	24.78	£3,143	£127
		40	27.61	£3,143	£114
VD	VIC	30	0.22	£3,143	£14,286
		40	2.69	£3,143	£1,168
VD	VIC-D	30	3.90	£3,143	£806
		40	6.38	£3,143	£493
VD	VID	30	7.59	£3,143	£414
		40	10.06	£3,143	£312
VD	VI-VIIC	30	3.90	£3,143	£806
		40	6.38	£3,143	£493
VD	VI-VIIC-D	30	9.77	£3,143	£322
		40	12.25	£3,143	£257
VD	VI-VIID	30	15.64	£3,143	£201
		40	18.12	£3,143	£173
VD	VIIC	30	7.59	£3,143	£414
		40	10.06	£3,143	£312
VD	VIIC-D	30	15.64	£3,143	£201
		40	18.12	£3,143	£173
VD	VIID	30	23.69	£3,143	£133
		40	26.17	£3,143	£120
V-VIC	VIC	30	1.19	£3,143	£2,641
		40	3.99	£3,143	£788
V-VIC	VIC-D	30	4.88	£3,143	£644
		40	7.67	£3,143	£410
V-VIC	VID	30	8.56	£3,143	£367
		40	11.36	£3,143	£277
V-VIC	VI-VIIC	30	4.88	£3,143	£644
		40	7.67	£3,143	£410
V-VIC	VI-VIIC-D	30	10.75	£3,143	£292
		40	13.54	£3,143	£232
V-VIC	VI-VIID	30	16.61	£3,143	£189
		40	19.41	£3,143	£162
V-VIC	VIIC	30	8.56	£3,143	£367
		40	11.36	£3,143	£277
V-VIC	VIIC-D	30	16.61	£3,143	£189
		40	19.41	£3,143	£162
V-VIC	VIID	30	24.67	£3,143	£127
		40	27.46	£3,143	£114
V-VIC-D	VIC	30		£3,143	
		40	0.82	£3,143	£3,814
V-VIC-D	VIC-D	30	2.49	£3,143	£1,262
		40	4.51	£3,143	£697
V-VIC-D	VID	30	6.18	£3,143	£509
		40	8.19	£3,143	£384
V-VIC-D	VI-VIIC	30	2.49	£3,143	£1,262
		40	4.51	£3,143	£697
V-VIC-D	VI-VIIC-D	30	8.36	£3,143	£376
		40	10.38	£3,143	£303

V-VIC-D	VI-VIID	30	14.23	£3,143	£221
		40	16.25	£3,143	£193
V-VIC-D	VIIC	30	6.18	£3,143	£509
		40	8.19	£3,143	£384
V-VIC-D	VIIC-D	30	14.23	£3,143	£221
		40	16.25	£3,143	£193
V-VIC-D	VIID	30	22.28	£3,143	£141
		40	24.30	£3,143	£129
V-VID	VIC-D	30	0.11	£3,143	£28,573
		40	1.35	£3,143	£2,328
V-VID	VID	30	3.79	£3,143	£829
		40	5.03	£3,143	£625
V-VID	VI-VIIC	30	0.11	£3,143	£28,573
		40	1.35	£3,143	£2,328
V-VID	VI-VIIC-D	30	5.98	£3,143	£526
		40	7.22	£3,143	£435
V-VID	VI-VIID	30	11.85	£3,143	£265
		40	13.08	£3,143	£240
V-VID	VIIC	30	3.79	£3,143	£829
		40	5.03	£3,143	£625
V-VID	VIIC-D	30	11.85	£3,143	£265
		40	13.08	£3,143	£240
V-VID	VIID	30	19.90	£3,143	£158
		40	21.14	£3,143	£149
VIC	VIC-D	30	3.68	£3,143	£854
		40	6.09	£3,143	£516
VIC	VID	30	7.37	£3,143	£426
		40	9.78	£3,143	£321
VIC	VI-VIIC	30	3.68	£3,143	£854
		40	6.09	£3,143	£516
VIC	VI-VIIC-D	30	9.55	£3,143	£329
		40	11.96	£3,143	£263
VIC	VI-VIID	30	15.42	£3,143	£204
		40	17.83	£3,143	£176
VIC	VIIC	30	7.37	£3,143	£426
		40	9.78	£3,143	£321
VIC	VIIC-D	30	15.42	£3,143	£204
		40	17.83	£3,143	£176
VIC	VIID	30	23.47	£3,143	£134
		40	25.88	£3,143	£121
VIC-D	VID	30	3.68	£3,143	£854
		40	4.89	£3,143	£643
VIC-D	VI-VIIC	30		£3,143	
		40	1.20	£3,143	£2,619
VIC-D	VI-VIIC-D	30	5.87	£3,143	£535
		40	7.07	£3,143	£445
VIC-D	VI-VIID	30	11.74	£3,143	£268
		40	12.94	£3,143	£243



VIC-D	VIIC	30	3.68	£3,143	£854
		40	4.89	£3,143	£643
VIC-D	VIIC-D	30	11.74	£3,143	£268
		40	12.94	£3,143	£243
VIC-D	VIID	30	19.79	£3,143	£159
		40	20.99	£3,143	£150
VID	VI-VIIC-D	30	2.18	£3,143	£1,442
		40	2.18	£3,143	£1,442
VID	VI-VIID	30	8.05	£3,143	£390
		40	8.05	£3,143	£390
VID	VIIC-D	30	8.05	£3,143	£390
		40	8.05	£3,143	£390
VID	VIID	30	16.10	£3,143	£195
		40	16.10	£3,143	£195
VI-VIIC	VI-VIIC-D	30	5.87	£3,143	£535
		40	7.07	£3,143	£445
VI-VIIC	VI-VIID	30	11.74	£3,143	£268
		40	12.94	£3,143	£243
VI-VIIC	VIIC	30	3.68	£3,143	£854
		40	4.89	£3,143	£643
VI-VIIC	VIIC-D	30	11.74	£3,143	£268
		40	12.94	£3,143	£243
VI-VIIC	VIID	30	19.79	£3,143	£159
		40	20.99	£3,143	£150
VI-VIIC-D	VI-VIID	30	5.87	£3,143	£535
		40	5.16	£3,143	£609
VI-VIIC-D	VIIC-D	30	5.87	£3,143	£535
		40	5.16	£3,143	£609
VI-VIIC-D	VIID	30	13.92	£3,143	£226
		40	13.21	£3,143	£238
VI-VIID	VIID	30	8.05	£3,143	£390
		40	5.42	£3,143	£579